DEVELOPMENT AND TESTING OF A MANUALLY OPERATED PADDY DIBBLER

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Technology in Agricultural Engineering

Faculty of Agricultural Engineering
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Department of Farm Power Machinery and Energy
Kelappaji College of Agricultural Engineering and Technology
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1992

Dedicated to

My Pappa and Amma

DECLARATION

I hereby declare that this thesis entitled "**Development and Testing of a Manually Operated Paddy Dibbler**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Tavanur,
11th November, 1992.

BINI SAM

CERTIFICATE

Certified that this thesis entitled **"Development and Testing of a Manually Operated Paddy Dibbler"** is a record of research work done independently by **Miss Bini Sam** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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We, the undersigned, members of the Advisory Committee of **Miss Bini Sam**, a candidate for the degree of Master of Technology in Agricultural Engineering with major in Farm Power and Machinery, agree that the thesis entitled **"Development and Testing of a Manually Operated Paddy Dibbler"** may be submitted by Miss Bini Sam in partial fulfilment of the requirements for the degree.

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BINI SAM

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SYMBOLS AND ABBREVIATIONS

Agric.	-	Agricultural
ASAE	-	American Society of Agricultural Engineers
cc	-	cubic centimetre(s)
CIAE	-	Central Institute of Agricultural Engineering
cm	-	centimetre(s)
cv	-	coefficient of variation
deg	-	degree
Dept.	-	Department
Engng	-	Engineering
et al.	-	and other people
Fig.	-	Figure
g	-	gram(s)
ha	-	hectare(s)
hp	-	horse power
h	-	hour(s)
IRRI	-	International Rice Research Institute
ISAE	-	Indian Society of Agricultural Engineers
J.	-	Journal
KAU	-	Kerala Agricultural University
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
kg	-	kilogram(s)

kmph	-	kilometres per hour
kpa	-	kilo pascal
lab	-	laboratory
m	-	metre(s)
mm	-	millimetre(s)
Pa	-	Pascal
rpm	-	revolution per minute
s	-	second
/	-	per

Introduction

INTRODUCTION

Agriculture is as old as civilization and for centuries mankind has attached to develop it to match with the environments. In Indian context, agriculture is the backbone of the economy since 80 per cent of population of this second most populated country depends on it.

Indian Agriculture, after partition of the country in 1947, has undergone a marked change.. Prior to the recent technological breakthrough in Indian Agriculture, farming was by and large of subsistence nature. The farmers used mostly inputs which were raised on the farms and production was largely consumption oriented. On the contrary, the recent technological breakthrough has, no doubt, made it possible to achieve spectacular growth rate in agricultural production but it has also placed manifold demand on inputs, as different components of new farm technology involve increasing reliance on the purchase of non-conventional inputs in contra-distinction to the old traditional inputs. Therefore, adoption of high yielding varieties, coupled with multiple-cropping forced the farmers to use higher doses of inputs and, consequently, the demand for energy increased considerably.

Energy is the nucleus of all the technical developments and a key variable in economic development. In agriculture, inputs to increase production and productivity cannot be effectively utilized without availability of adequate power from any suitable source in the desired form.

An increase in agriculture production is possible through additional land use, energy resources in the form of seed, fertilizer and irrigation and efficient management of power machine system. The relationship between power input and yield has been eminently correlated by Mr. Giles. He showed that as the power input went up from 0.13 hp per hectare to 2.05 hp per hectare, the yield increased from less than 1 ton per hectare to about 6 tons per hectare.

Rice is the most important and extensively cultivated food crop of Kerala. The state of Kerala has a total area of 21.84 lakh hectares under cultivation, of which 7.4 lakh hectares is covered by rice (Directorate of Economics, Trivandrum, 1984-'85).

Generally for rice cultivation, two methods are followed, transplanting and direct sowing. In Kerala, rice establishment is practised mainly through manual transplanting of paddy seedlings. Manual transplanting is not only a labourious, time consuming and costly operation but also results in non-uniform and inadequate plant population. Approximately, more than 25 per cent of the total working hours for paddy production is spent for the process of transplanting and nursery raising. Plant spacing is an important production factor in paddy cultivation. Planting paddy seedlings closer than necessary increases the cost of transplanting.

Direct seeding of rice on dry soils has been found the most appropriate alternative to transplanting. It not only avoids puddling operations, raising and transplanting of nursery seedlings but also gives better yields than existing manual transplanting. In China an average rice yield of 6.75 ton per hectare was recorded with direct dry cultivation by using one-third as much water and two-third as much manure as needed with traditional method (Qinghua, 1985). Another study in China reveals that direct sowing of rice on dry soil save about one-third of irrigation water and 90 man-hours as compared with transplanted rice (Guo Yixian, 1986). Dry direct seeding of rice may be the most suitable substitute to conventional transplanting because of:

1. Saving in water requirements by elimination of seedling raising and puddling operations.
2. Minimum production cost by less labour requirement
3. Timely sowing of rice crop
4. Optimum plant population of rice crop

Direct sowing can be done by broadcasting, drilling and dibbling.

Broadcasting is the process of random scattering of seeds on the surface of seed bed. This results in seed damage by birds and poor germination due to insufficient soil moisture at the surface. The broadcast crops also lack evenly-spaced rows which hinder interculture and pesticide application operations.

Drilling consists of dropping the seeds in furrow lines in a continuous flow and covering them with soil. The seed to seed spacing in row crop drilling is difficult to maintain and thus plants do not get adequate amount of sunlight, water and even nutrients due to crowding in rows.

The third method is dibbling. It is the most efficient method of direct sowing. Dibbling is the process of placing the seeds in holes made in seed bed and covering them. In this method, seeds are placed in holes made at definite depth at fixed spacing. This accurate spacing of the seeds is necessary for the introduction of high yielding varieties. The spaced planting of seeds in rows also provides enough opportunity for each plant to grow with high vigour and yield 7 to 15 per cent more when same number of plants are drilled in rows (Cop, 1960 and Sweetman, 1957). This also reduce the seed requirements. Intercultural operations using mechanical devices are easier as the plants are in fixed rows. Other distinctive advantage is that it helps in improving seedling emergence parameters such as higher total emergence, faster emergence and shorter spread of emergence. This improved emergence leads to a better harvest.

Large scale intensive mechanisation using four wheel tractors and power tillers has limitations on Keralite farms, from the point of view of large number of small and medium farmers, small and fragmented holdings and high initial investment. The possible alternative of dependence on animal draft power, is also restrictive, due to their poor efficiency and the drain they cause to the capital and land resources of the nation. Due to these reasons and also after giving due consideration to the attitude of the rural lot of Kerala, who shun agriculture mechanisation fearing unemployment problem, a selective mechanisation incorporating both man and machine acquires added significance.

Considering the above facts and also the numerous advantages in using a dibbler, it is proposed to develop a manually operated dibbler for dry sowing of paddy with the following objectives:

1. To develop a paddy dibbler with suitable seed metering device.

2. To optimise the number of rows for the paddy dibbler such that it can be operated by one man.

3. To fabricate a suitable frame for the manual operation.

4. To evaluate the manually operated paddy dibbler.

Review of Literature

REVIEW OF LITERATURE

The old adage, "as you sow, so shall you reap" is as much true in agriculture as it is true metaphorically. Sowing of an agricultural crop involves consideration of the correct seed rate, proper placement with respect to the depth and distance between seed to seed in the same row, proper row width, correct application of fertilizer with respect to the quantity and the placement and proper coverage and compaction of the seed. The crop stand and yield depends on proper sowing of the crop.

This chapter deals with a brief review of practices of paddy farming, different sowing methods, development of different types of seed metering mechanisms, furrow openers, sowing machines and their testing and performance evaluation.

Rice can be grown as transplanted or direct sown crop during three seasons viz., viruppu, mundakan and punja depending on the availability of water and other local conditions.

2.1 Practices of paddy farming

Although large variation exists in various cultivation practices being adopted in different parts of the country, basically three systems of paddy farming are being followed in India. These are dry, semidry and wet systems.

2.1.1 Dry and semidry system

The dry system is basically followed in the areas dependent on rain water. In this system the land is prepared by ploughing and harrowing. The seed is sown directly with the onset of monsoon. The semidry system is also mainly confined to the tracts which depend on rains and do not have supplementary irrigation facilities. The land is prepared and seed is sown as above in the dry system. In addition, the rain water is impounded when the crop is about 6-8 weeks old and thereafter it is converted into the wetland system.

The various advantages of these systems are:

1. Labour cost is less.

2. Saving in water requirements by elimination of seedling raising and puddling operations.

3. Crop matures seven to ten days earlier than transplanted crop which may be important for multiple cropping.

4. Optimum plant population of rice crop.

Nakamura et al. (1984) provided key information necessary for the successful implementation of the direct seeding with coated rice in submerged paddy field system. Details of coating procedure, seeding operation, weed control, water management and manure management practice were discussed.

Choudary (1985) studied the effect of seed placement on seedling establishment in direct drilled fields.

The practice of direct drilling rice into submerged paddy fields and in-line drilling of fertilizer by the side were carried out by Fujioka (1986). Drilling rates was 100-150 grains/m^2 and seedling emergence was 60-120/m^2 (40-90 per cent). Overall direct drilling gave 10 per cent savings in cost and 20 per cent savings in labour as compared with the conventional method. Drilling fertilizer increases yield on an average of 5 per cent.

The experiment on direct drilling of rice into submerged paddy fields by Muravama (1987) revealed that the yield was 775 and 628 kg/acre with direct drilling as compared with 634 and 439 kg/acre with transplanting. Also the saving in cultivation time was about 10 hours per 10 acres.

Majid <u>et al</u>. (1989) conducted a study on the effects of different direct sowing techniques and date of sowing on rice production in clay loam soil. The seeding techniques used were: puddle broadcasting (PB), dryline sowing (DLS) and dry broadcasting (DB). The sowing dates were: May 16 (ST_1), May 31 (ST_2), June 16 (ST_3) and June 30 (ST_4). High grain weights of 22.2 and 25.8 g were associated with DLS and ST_1 treatments, respectively. Maximum grain yields 4365.3 and 6373.2 kg/hectare were obtained from the dryline sowing on May 16 while ST_4 had a decrease of 71.8 per cent in grain yield over ST_1 due to cold stress during grain formation.

Khan et al. (1989) pointed out that direct sowing was an alternative to paddy transplanting. The experiment conducted by them showed that transplanting produced maximum paddy yield of 7875 kg/hectare whereas the highest paddy yield of 8666 kg per hectare was recorded by direct rice cultivation on dry soils with an increase of 10 per cent over transplanting. Weed infestation was greater in the dry, direct rice cultivation (30 plants/m^2) compared with manual transplanting (7 plants/m^2).

The different methods employed in these systems are broadcasting, dibbling, seed dropping behind the plough, drilling, hill dropping and check rowing.

2.1.1.1 Broadcasting

Broadcasting is one of the oldest methods of sowing paddy seeds. Broadcasting, distributes seeds on the surface of the soil where it is covered by further tillage. As a method of seeding, broadcasting is not as efficient as drilling because of the variable depth of coverage, some seeds being too deep and others too shallow, which leads to uneven germination, while inter-row cultivation afterwards is either difficult or impossible. It is also wasting of seed.

2.1.1.2 Dibbling

Dibbling means placing two or more seeds in holes made in the soil either by hand tools or by some implement. It is the most efficient method because of lower seed requirement, uniform sowing in lines and uniform crop stand and it reduces the cost and labour requirement to nearly one-third as compared to transplanting.

2.1.1.3 Seed dropping behind the plough

This method is used for larger seeds like maize, peas, gram and also successfully used for wheat and barley. Since the depth of seeding is comparatively little, it is generally observed that seed rates are increased and the moisture content of the soil is kept slightly higher. The usual method is to use indigenous plough to open a furrow in which a man or woman following the plough drops the seed by hand. When the next furrow is opened, the previous one gets partially filled.

2.1.1.4 Drilling

Drilling means dropping the seeds in the furrow through seed tubes. Metering of seed may either be done manually or mechanically. Some of the mechanically operated seed drills give a very high accuracy and metering. The number of rows planted at a time may be one or more. The disadvantage is that mechanical seed drills may damage the seed and are likely to get clogged during operation. This may result in irregular germination of the crop.

2.1.1.5 Hill dropping

In this method seeds are sown in lines as in drilling and the seed dropping in line is also controlled. Unlike drilling the seeds are dropped at a fixed spacing, not in a continuous stream. Thus the spacing between the plants in a row is constant. But the spacing between rows is not the same as that between the plants in a row.

2.1.1.6 Check rowing

Check rowing is the method in which the spacing between the rows is the same as that between the plants. This method makes it possible to do interculture operations from both directions.

2.1.2 Wet system

Under this system the land is ploughed thoroughly and puddled with 3 to 5 cm of standing water in the field. In this system the sprouted seeds are either directly sown in a puddled soil or alternatively grown in a nursery and then transplanted into the field.

The wet system has a series of advantages which are enlisted below:

1. A good levelling of land is ensured for better water management.
2. Less seed is required.
3. The seedling can be selected before transplanting and hence uniform crop stand in the field is obtained.
4. The availability of most of the plant nutrients such as phosphorus, iron and potassium is increased and nitrogen is conserved better.
5. The weeds are buried at the time of puddling and hence the weed problem is reduced.
6. Plant protection measures can be effectively used in the nursery.
7. The treatment of seedlings for nutrient deficiencies and for protection against pests and disease is facilitated before transplanting.

The disadvantages of wet system of farming are as follows:

Raising the nursery and then transplanting the seedlings in the field not only involves many additional costs but also demand considerable amount of manpower. As estimated, approximately 435 man-hours are required to transplant the seedlings in one hectare of field. This creates a big demand of manpower during the days of transplanting. This demand is increasing rapidly due to the increasing area under cultivation and thus the scarcity of labour during peak hours is considerable. The scarcity of manpower during peak season not only increases the labour charge but also delays the timely transplanting of the seedlings which ultimately reduces the yield. The other disadvantage is that the seedlings are exposed to possible injury during handling and also the plants tend to grow more slowly than direct seedling because of recovery time after transplanting.

2.1.2.1 Transplanting

Transplanting is a method of raising the seedlings in nursery and then planting them in the field at desired spacings. The seedlings raised in the nursery are transplanted to the fine tilled plot usually within 20 to 25 days of age. Two or three seedlings are planted at 20 x 10 cm or 20 x 25 cm spacing in levelled fields, as per the agronomic practices.

2.1.2.2 Broadcasting sprouted seeds in puddled soils

In this method the paddy crop is raised by directly placing the sprouted seeds in the wet field. This avoids the need of raising the nursery and then transplanting the seedlings into the field, thus reducing the cost and manpower requirement and ensuring the timely sowing of crops.

2.2 Sowing machines

The various types of sowing machines used in India are seed drills, seed cum fertilizer drills, planters, transplanters, dibblers, pre-germinated seeders and broadcasters.

2.2.1 Seed drill

Seed drill is a machine used for sowing seeds in rows at uniform depth with continuous flow. It performs the following mechanical functions.

1. It carries the seeds.
2. It opens furrows to a uniform depth.
3. It deposits the seeds in furrow in an acceptable pattern.
4. It covers the seeds and compact the soil around the seed.

2.2.1.1 Importance of seed drill in India

Seed drill plays an important role in the process of farm mechanisation. Seed drill was first designed by William T. Pennock of East Marlboro, Pennsylvania, which succeeded the old conventional method of broadcasting seeds. Adopting seed drill in farm has many advantages.

1. It saves much of the time taken when compared with conventional method of broadcasting.

2. Correct depth at which seed is to be placed in the soil for good germination, and correct spacing between plants are achieved, and

3. It reduces the plant population required per hectare and so the cost of cultivation per hectare is brought down.

2.2.1.2 Components of seed drill

1. Frame

The frame is usually made of angle iron with suitable braces and brackets. The frame is strong enough to withstand all types of loads in working condition.

2. Seed box

It may be made of mild steel sheet or galvanised iron with a suitable cover. A small agitator is sometimes provided to prevent clogging of seeds.

3. Seed metering mechanism

The mechanism of seed drill or fertilizer distributor which delivers seed or fertilizer from the hopper at selected rates is called seed metering mechanism.

4. Furrow opener

The furrow openers are provided in a seed drill for opening the furrows before dropping the seeds. The seed tube conducts the seed from the feed mechanism into boot from where they fall into furrows.

5. Covering device

It is a device to refill a furrow after the seed has been placed in it. Covering the seeds are usually done by patta, chains, drags, packers, rollers or press wheels designed in various sizes and shapes.

6. Transport wheels

There are two wheels fitted on the main axle. Some drills have got pneumatic wheels also. The wheels have suitable attachment to transmit power to operate seed dropping mechanism.

7. Boot

It is a part of the sowing machine which conveys the seeds or fertilizers from the delivery tube to the furrow. It is a hollow casting into which the lower end of the seed tube is inserted and to which the furrow openers are attached.

8. Seed tube

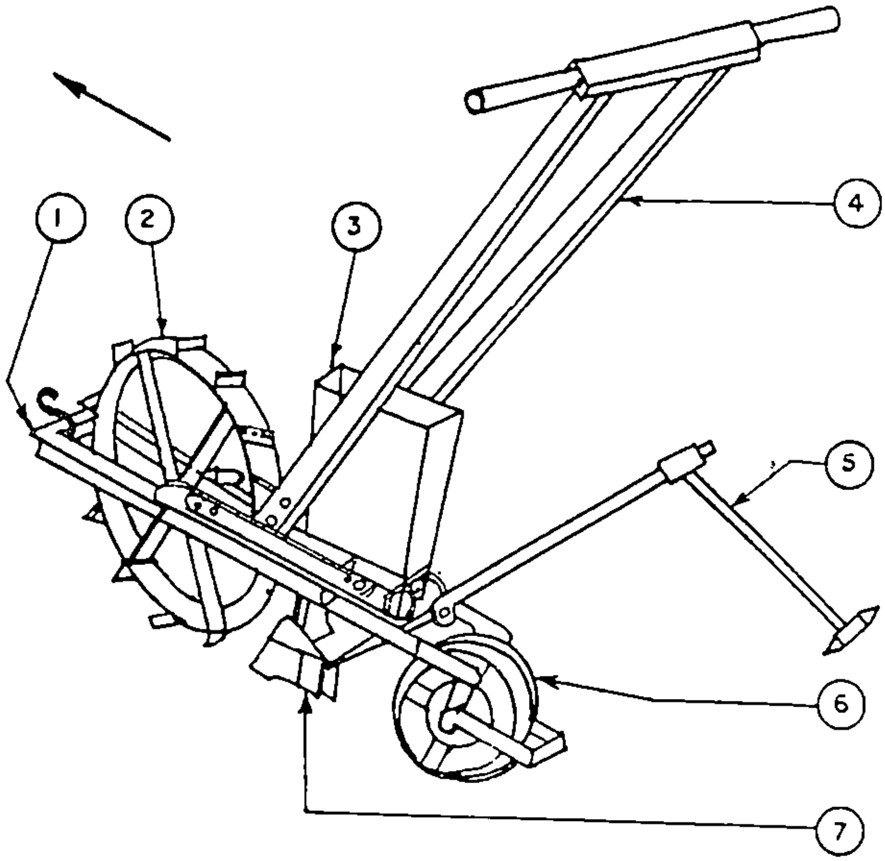
It is a tube which carries the seeds from the metering device to the boot. Seed tubes are provided at the lower end of the feed cups. They conduct seeds from feed cups to the furrow lines through suitable boots and furrow openers. The most common type of seed tube is the steel ribbon one. Polythene or rubber tubes are also used for this purpose.

The details are shown in Fig.1.

2.2.1.3 Development of seed drill

Harries (1928) developed a drill which sows steadily and continuously without crushing the seed and was equipped with coulters adjustable to various widths. Quantity of grain sown was regulated by multiple gear disc with which driving pinion engages. The movement of a small pointer on an index plate regulated the driving pinion and fixed the quantity of grain.

Russells (1957) developed a seed drill, which had ground driven selector wheel with a double row of cells in the rim. Seeds were picked from the base of the hopper and at the lowest point they were expelled by a small toothed wheel, which engaged the cells like an internal gear. The seed fell one at a time into the furrow formed by the boot shaped coulters and adjustable coverers and a rear press wheel completed the job.



(1) FRAME
(2) DRIVE WHEEL
(3) SEED HOPPER
(4) WOODEN HANDLE
(5) MARKER
(6) PRESS WHEEL
(7) FURROW OPENER

FIG.1 SUGARBEET DRILL

(Gite *et al.*, 1981)

The standard machine planted at 3.2 cm spacing and alternative distances were possible.

Hervath (1958) developed a pneumatic precision seed drill whose principal component was a hollow drum with a series of holes in its periphery rotating on a tubular shaft through which air could be exhausted. Drum was half immersed in seed hopper so that single seed was held by suction. As the drum revolved, a scraper caused the seeds to drop off.

Fuss et al. (1959) utilised a revolving member or spinner in a seed drill to cause accurate distribution of seeds. This member was of special shape and instead of throwing the seeds outward on to the ground it diverted the seeds to the delivery tubes where air blast conveyed the seeds to exact localities at the terminal end of the tubes.

Nolle (1964) developed a seed sower which comprised of a hopper and an agitator by means of a rod connected to a crankpin or a wheel. Material was fed through a rectangular aperture in the bottom of the hopper which could be adjusted.

Mekhaniz (1964) conducted experiments on increasing the accuracy of drilling. He found that forward speed of drill, height from the point of ejection of seed to furrow bottom and the distance travelled during the flight of seeds were the main parameters for the accuracy of drilling.

Dodwell (1964) developed a pneumatic seed sowing device which comprised of a hopper that rotates with an endless belt with holes. Seed was picked by the belt opening and discharged down. Compressed air was used to discharge the seeds from openings.

Cameron et al. (1967) fabricated an automatic self propelled seed drill for drilling cereals.

Chauhan et al. (1972) studied different seed drills available in India and gave a report of their special features.

Khan (1972) reported the development of manually operated eight row seeder, which was claimed to be 40 times faster than that of transplanting.

Srivastava (1975) developed a manually operated, single row seed drill with a metering device provided with nylon brush type agitator over adjustable orifice for sowing sugarbeet seeds. Under the field trials the drill had given satisfactory performance with a field capacity of 0.8 hectare per day (8 hours) at a walking speed of 2.5 km per hour for sowing dry unpolished sugarbeet seeds at uniform depth.

The Tume precision drill from Benedict Ltd., (1981) employs monoseeder unit attached to a carrying box. Seed placement was by a selector wheel with an ejector plate. Seedling emergence from this relatively simple machine averaged out at 82 per cent.

A bullock drawn paddy seeder based on the manually operated seeder of IRRI design was modified by Singh et al. (1983) and evaluated in the lab as well as in the field. The observations on man-hour required per hectare, total power required for one hectare cultivation, plant population per square metre, grain and straw yields, total input and output costs etc. were made. After the two year's test data it was found that the total man-hour requirement per hectare was only minimum i.e., 1443 in the case of bullock drawn paddy seeder and in the case of manual transplanting method it was 1682. It was found that there was no significant difference in the grain and straw yields for bullock drawn seeder and transplanted paddy. The cost of cultivation was minimum in the case of seeder.

Seedling depth control system for the rice seeder used in submerged paddy field was studied by Murase et al. (1985). The study revealed that the buoyancy increases when the seed was surrounded by oxygen produced by the coating or chemical.

Kumar et al . (1988) developed a direct paddy seed drill with an operating width of one metre. The unit was mounted over a levelling board cum float so that complicated structures like frame, wheels etc. could be eliminated and the design was simplified. The orifice type metering mechanism with agitator was used. The furrow openers were wedge shaped and they were designed to leave in the soil a 'U' shaped furrow.

Senapati et al. (1988) tested six seeding devices under dryland condition. In each case the amount of energy utilization in drilling the seeds and seed distribution efficiency have been determined and grain yield on the experimental fields has been observed. Manually operated seed drills performed better in the field than the animal drawn drill. The performance of the latter was low because of the operational difficulties encountered during the operation of the seed drills.

Duraisamy et al. (1991) developed a tractor drawn direct paddy seeder. The seeder was so desiged that the existing tractor drawn tyne cultivator could be used as a seed box mounting frame-cum-furrow opener. The seed metering device consists of a seed box and a feed type seed metering mechanism with 18 twin cups fitted on both sides of the seed metering disc. This machine ensures uniform coverage and line sowing of paddy, which were not possible by manual broadcasting. The average coverage of the unit was 0.4 hectare per hour. The cost of seeding works out to Rs.141.20 per hectare.

2.2.2 Seed cum fertilizer drill

These are seed drills equipped with fertilizer attachment which distribute the fertilizer evenly beside the row in which seeds are placed. With small grains, it is recommended that the fertilizer should be placed in partial contact with the seed to give good results. The details are shown in Fig.2.

2.2.2.1 Development of seed cum fertilizer drill

Jones et al. (1951) evaluated the application of multiple use drill which performs the tillage operation, sows the seed and applies fertilizer in a single operation. The drill consists of a conventional drill grain box suitably modified and mounted on a tiller with seed and fertilizer tubes attached to each opener. He found that a saving of at least 50 per cent over conventional methods was obtained.

Yadav et al. (1977) developed a simple and low cost bullock drawn bukkhar cum ferti-seed drill satisfying all the requirements of ploughing, weeding and sowing operations in arid zone condition. Field trial on stand establishment of wheat, mustard, bajra and mung showed good stand of crop sown with this drill.

A three row animal drawn seed cum fertilizer drill cum two row planter has been developed by Srivastava et al. (1985)

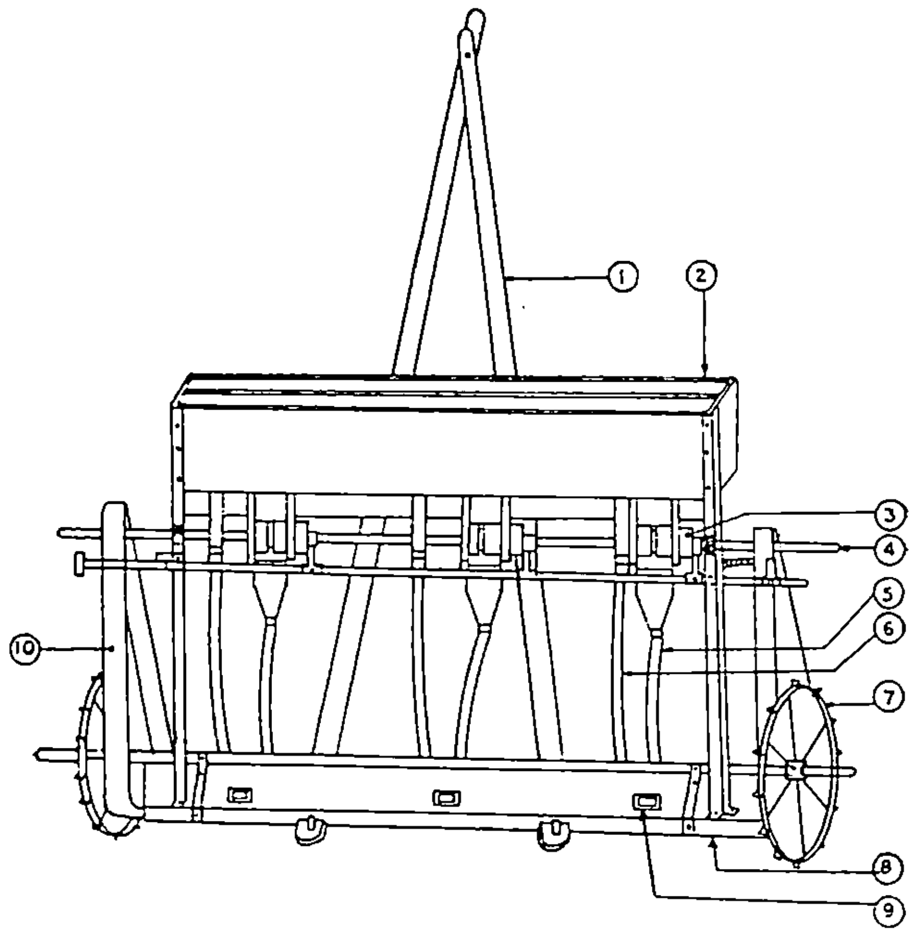


FIG.2 SEED-CUM-FERTILIZER DRILL

(Gite et al., 1981)

for drilling of crops like soyabean, sorghum, wheat, pigeonpea and Bengal gram and planting of maize, groundnut and cotton under black soil conditions. The draft of the machine was in the range of 45-65 kg depending upon the soil type and moisture content. The field capacity of the machine ranged between 0.1 to 0.25 ha/h depending on the row spacing.

Varma _et al_. (1985) evaluated eight different seeding and fertilizer application methods for sowing of wheat in silty loam soil. The results showed that wheat sowing by seed cum fertilizer drill was advantageous over other methods of sowing. It gave 32.41 per cent higher yield and 41.22 per cent and 50.39 per cent savings in manual and animal energy respectively and 58.51 per cent saving in cost of sowing of wheat in comparison to traditional method of sowing and fertilizer application.

Sriram _et al_. (1988) developed a three row seed cum fertilizer drill. It has got many unique features. The first was the drastic reduction in draft which means that the local animals could pull it with effortless ease. This has been made possible by special type openers and an innovative device welded to the shanks of the openers which discharges fertilizer by the side of emerging seedlings, the nutrition needed to plants immediately after emergence. This machine was a great saver of time, highly efficient in terms of coverage, reduces draft and highly economical.

Dublin (1989) evaluated the performance of two fertilizer spreaders (one pneumatic and the other with spinning disk distributor) sowing in submerged and dry soil. When the sowing was done in the dry soil the sowing operation time was by 20 per cent lower. Moreover the pneumatic fertilizer spreader, with the same good performance either in dry or in submerged soil, permitted an increase of the yield by 27 per cent compared with the yield reached with the traditional spinning fertilizer distributor.

Sharma et al. (1989) conducted a study to evaluate the effect of use of the seed cum fertilizer drill on wheat yield, energy input and cost of operation in comparison with the traditional method. The animal drawn mechanical sowing has resulted in a 10.4 per cent increase in yield, 49.1 per cent savings in energy and 49 per cent savings in the cost of operation.

Khan et al. (1990) studied the power transmissions, metering and seed placement mechanism of two imported seed cum fertilizer drills. The Aitchison drill with infinitely variable speed oil-bath gear box was found more suitable as it could deliver a wide range of seed rates to suit most of the common crops. The inverted 'T' furrow openers were best suited for better seed germinations. The drill could be used in both tilled and no-tilled field conditions and for direct seeding of wheat on rice stubble fields.

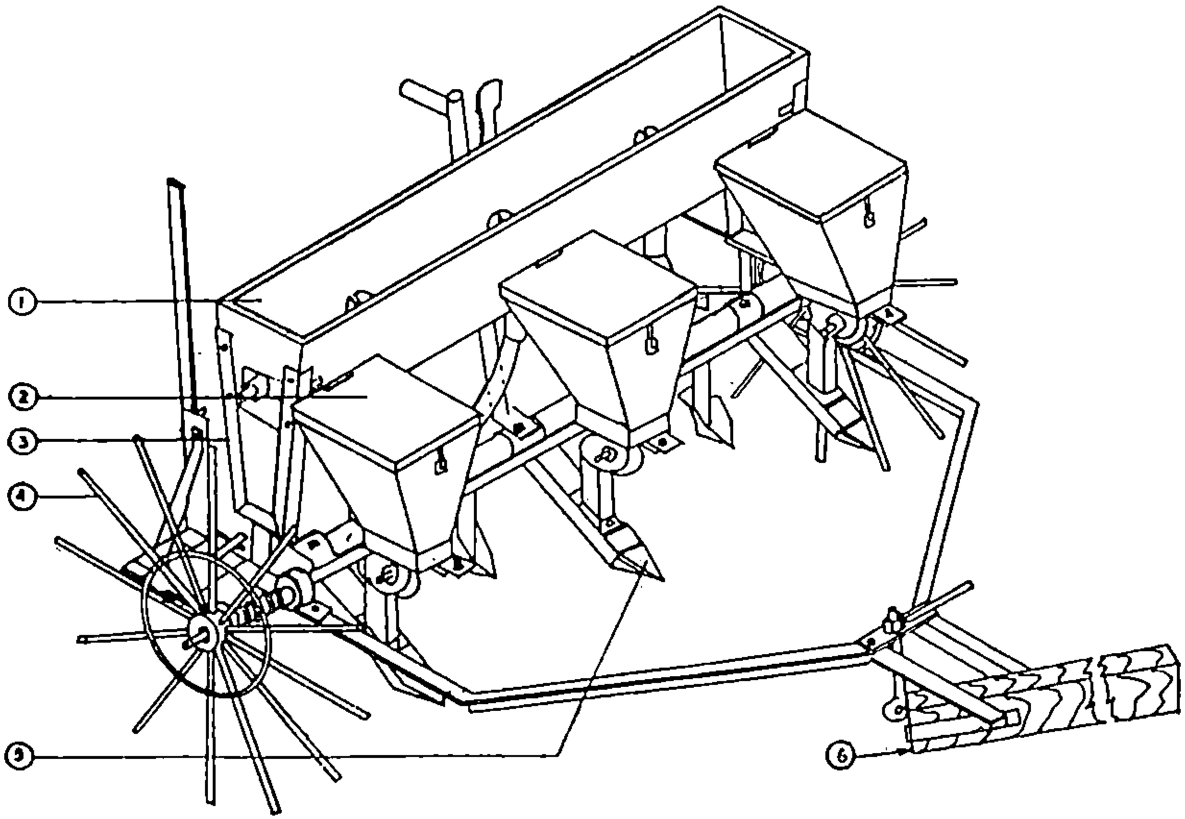
Varshney et al. (1991) developed a power tiller drawn seed cum fertilizer drill. The unit mainly consists of main frame, seed and fertilizer box, flutted roller type metering mechanism, ground wheel, furrow openers, depth adjustment mechanism and hitching arrangement. The hitching arrangement consists of power tiller hitch point, swivel pin and seed drill hitch bracket. Swivel action of the hitch facilitated easy turning. The clearance provided between the power tiller hitch point and hitch bracket takes care of slight vertical misalignment of the seed drill with the power tiller.

2.2.3 Planter

Planter is used for hill dropping or check row planting of larger seeds than those which normally go through seed drills. They have more accurate results with larger seeds. Planters are provided with a seed hopper for each row. The rows are far apart to allow intercultivation. The details are shown in Fig.3.

2.2.3.1 Development of planter

Mcbirney (1946) developed a sugarbeet planting equipment. The best distribution was obtained by using seed of a comparatively small range in size. By changing the seed plates and changing the row spacing the planter could be used for other seeds.



(1) FERTILIZER HOPPER (2) SEED HOPPER (3) FRAME
(4) GROUND WHEEL (5) FURROW OPENER (6) BEAM

FIG.3 JYOTI PLANTER

Gite _et al_., 1981)

Bainer *et al*. (1947) developed a precision planting equipment for beet and corn.

Brubn *et al*. (1947) designed and evaluated a mechanical tree planter.

Vjerkan (1947) studied the performance of different components of a planter and found that high planting speeds, slippage of ground wheels and non uniform seed size to be the causes of irregular planting.

Collins *et al*. (1948) studied the mathematics of a cumulative drop planter. He derived three mathematical probability expressions which predicted the accuracy with which hills of any desired number of seeds would be accumulated.

Autry (1953) gave the design factors for hill drop horizontal plate planters and studied the effect of cell shape, uniformity of seed size, accuracy of planting, dispersion characteristics and effect of ground speed on seed dispersion at various heights of fall.

Fabian (1964) developed a high speed precision planter with an accurate metering mechanism to separate and eject individual seeds, at a predetermined distance. He also developed a seed plate test stand for establishing seed and plate performance.

Keneeth (1966) found that for satisfactory precision planting, three requirements need to be satisfied. They were uniform size and shape of seed for accurate metering, biological uniformity for ensuring uniform response and uniform seed bed.

Wanjura et al. (1968) studied the metering and seed-pattern characteristics of a horizontal edge-drop plate planter. Metering variations occur among seed hoppers on the same planter. These fluctuations were caused mainly by the hopper bottoms followed by plate speed and then plates.

Hudspeth et al. (1970) developed a planter for precision depth and placement of cotton seed in which vacuum wheel for single seed metering, was incorporated. A seed hopper was attached in a position that exposed the wheel to the seed supply for about 90° of its rotation. Each suction port picked up seed while passing through the seed box, retaining it until the bottom centre point of its rotation was approached. The vacuum was broken at the bottom centre point and the seed was released.

A pneumatic paddy planter has been designed, fabricated and tested by Yadav (1976). The planter performed satisfactorily for different varieties of paddy in dry and puddled soil.

Odigboh (1978) developed a two row automatic cassava cutting planter. The planter prototype was trailed, tractor drawn at speeds upto 10 km/h. It was designed to plant cassava cuttings at an inclination of upto 80° to the horizontal, depending on planter speed and spaced 870 mm on small ridges which were 900 mm apart.

Gupta (1982) evaluated the performance of a potato planter over conventional method of potato planting by manual khurpa method. He noticed that the yield was 5 to 7 per cent higher when it was sown by potato planter. The crop was also seen healthy and mature in case of potato planter.

Sandge et al. (1982) developed a manually operated single row jyoti planter. For planting and sowing different seeds, wooden seed plates carrying cells or grooves of different size and number were used. It was found that the germination of the seed was uniform. The average depth of sowing was 4 cm.

Shukla et al. (1984) developed a drop type, two row tractor drawn semi automatic sugarcane planter with a unique feature of rotating drum for uniform placement of the sets. It opens the furrow, places sets, chemical and fertilizer and covers as well as compacts the cover. It's effective field capacity was 0.5 acre/h and the forward speed was about 2 km/h. The uniformity of sets dropping was fairly good upto 2.5 km/h forward speed.

Baloch et al. (1985) modified and tested a bullock drawn single row corn planter. The planter was modified by mounting a metering device (wooden roter) in between the bowl and tube to give uniform spacing between seeds. The modified implement was then tested and found useful as compared with a conventional one.

Sharma et al. (1985) invented a two row ridge planter for planting winter maize. The unit consists of a three bottom ridger, seed hopper with two inclined plate seed metering devices, a ground wheel and two horizontal sliding furrow openers. The planter made ridges and planted maize seeds on one side of the ridge at an average seed to seed distance of 19.8 cm, row spacing of 60 cm and ridge height of 25 cm.

Varshney et al. (1985) developed and evaluated a bullock drawn semi automatic potato planter. The planter was able to place the potato seeds at a spacing of 12 to 18 cm and fertilizer in a continuous stream 4 to 6 cm below the seed. The planter had the provision of varying the spacing of seed and fertilizer rate.

Morrison et al. (1985) evaluated planter depth control with four wheel designs on the basis of the predicted effects on stimulated emergence for four crops.

Khalid (1987) developed a surgarcane planter which was a two-row machine integrally mounted on the rear of a tractor through three point linkage. It opens the furrows, cuts the sets and directs them into the furrows, applies fertilizer and covers the sets with soil. Row to row distance was fixed at 1000 mm. The machine was designed to plant double sets end to end but could be adjusted to give desired seed rate.

Fashima (1987) developed a manual seed planter having three metering plates which have different numbers of cups welded on to it. The movement from the front wheel was transferred to the seed plate through sprockets. The seed in each cup was released through a hole to the seed tube.

Yadav et al. (1987) developed a six row tractor drawn pneumatic precision planter to precisely plant rape seed, mustard, sorghum, soyabean, pigeonpea, maize, onion seed etc. The machine could plant on an average 0.5 to 0.6 ha/h at full width of tool bar. The performance of the machine was quite satisfactory.

Manian et al. (1987) developed an improved bullock drawn seed planter for sowing groundnut. The unit consists of a simple frame on which the seed box, hitch bracket, handle, clutch mechanism and furrow closer were mounted. The seed to seed distance in a row could be adjusted by suitably changing the sprockets. By changing the size of cup, different varieties of seeds could be sown with this unit.

Yasin _et_ _al_. (1988) developed a sugarcane planter which consists of main frame, furrow openers, cane feeding chutes, set cutting mechanism, feeder seats and space for storing of canes. The machine was mounted behind the tractor with three point linkage and was powered through trator PTO shaft. It plants 53000 to 87000 sets per hectare. It saves 80 man hour per hectare which was otherwise required for set cutting. The best planting could be achieved while operating the planter in first low gear at 1200 rpm and in second low gear at 1200 to 1400 rpm.

A fully automatic tractor drawn sugarcane planter was designed and developed by Sharma _et_ _al_. (1990). All the operations involved in sugarcane planting viz., opening of furrow, dropping of sets with desired overlapping, placement of insecticide and fertilizer and covering of sets with a blanket of soil, were accomplished in a single pass. A two row unit could be easily operated by a 35 hp tractor. The planter gave an output of 2.5 hectare per day.

Simalenga and Hatibu (1991) designed and developed a low cost hand operated planter. The design involved the development of a seed planter attachment which could be fastened to a typical hand-hoe and could be used to plant both maize and beans in a straight row.

2.2.4 Transplanter

The transplanter is used for planting the prepared seedlings in a paddy field after ploughing, puddling and levelling of the field. The depth of ponded water in the field does not exceed 3 cm and remains uniform all over the field.

In the beginning, seedlings are taken out of the box and placed in a rice transplanter, after checking and adjusting it. Transplanter speed is set about 0.6 to 0.7 m/s. This gives an output of 1/10th of a hectare per hour with the use of a two row machine.

2.2.5 Dibbler

Dibbler makes holes of definite depth at fixed spacing. Seeds are placed in these holes and then they are covered. It is generally used for smaller seeds. The row to row and plant to plant distance can be maintained.

2.2.5.1 Development of dibbler

Heinemann et al. (1973) developed experimental machines for autodibble planting. This type of planting had a number of advantages for small seeded row crops. A uniform, precisely spaced seedling emergence would be assured.

Wurr (1985) found that sowing with dibblers has improved emergence and leads to a better harvest in most of the crops.

Buffon *et al.* (1986) suggested that the use of dibblers to place seeds in the soil might offer a promising way towards obtaining better crop establishment by achieving better control of the soil physical environment.

John (1989) developed a five row bullock drawn dibbler for paddy. The machine consists of main frame, shaft, ground-wheels, seed box, seed tube, metering mechanism, furrow opener, furrow closer and clutch mechanism. The power from the ground wheel was transmitted to the shaft through a jaw clutch. Cams and agitators which were the integral part of the metering mechanism were fitted on the shaft. The agitator dropped the seeds from the seed box to the seed tube which was closed with a hinged gate. The opening cam and follower arrangement opened the seed tube instantly and dropped the seeds in the furrow. The furrow closer fitted at the back of the frame deflected loose soil over the furrow.

2.2.6 Pregerminated seeder

Pregerminated seeder is a machine for raising paddy crop by directly placing the sprouted seeds in the wet field.

2.2.6.1 Development of pregerminated seeder

Srivastava *et al*. (1982) developed a pregerminated seeder which was found to be an alternative to paddy transplanting. This machine avoids the need of raising the nursery and then transplanting the seedlings into the field, thus reducing cost and manpower requirement and ensuring timely sowing of crops.

Srivastava (1986) evaluated the performance of pregerminated paddy seeders. The crop stand was good and an average yield of 40 quintals per hectare was obtained at an average seed rate of 50 to 60 kg/ha. Some functional problems observed in the seeder were:

1. The increase in sprout length caused interlocking and restriction in seed flow and it reduced the seed rate.
2. Another reason for the reduction of seed rate was low bulk density of seeds with more sprout length.
3. Since ground wheel was in the centre of the machine, an imbalance was observed during field operation.

Srivastava *et al*. (1988) developed a six row manually operated pregerminated paddy seeder. It sows pregerminated paddy seed in puddled soil with an average field capacity of

0.18 hectare per hour. An average plant population of 162 and $174/m^2$ was obtained at seed rate of 86 and 108 kg/ha respectively. The seeder was recommended for use in area of labour scarcity and was suitable for an average Indian farmer due to its manual operation and low cost.

2.2.7 Broadcaster

Broadcaster is used for broadcasting the seeds over the field.

2.2.7.1 Development of broadcaster

Varshney et al. (1977) developed and evaluated a hand operated centrifugal broadcaster. This machine could effectively be used for uniform distribution of seeds and granular fertilizers. The distribution pattern of seeds was uniform after allowing necessary amount of overlapping. Hence a knowledge of overlap needed on each side for each material is essential.

Tajuddin et al. (1987) developed a device for broadcasting fertilizers and seeds. It consists of a plastic bucket as hopper. The hopper bottom had two openings through which material fall on a rotor plate made of 16 gauge aluminium sheet. The rotor plate had six curved projections on top. There was a handle provided in the device by rotating which, the rotor plate made 11 revolutions by means of suitable gear arrangements. There was provision for increasing or decreasing the opening area of hopper bottom. To avoid clogging an agitator was also provided. The rotor plate when rotated spreaded the material falling on it by centrifugal force.

Tajuddin (1989) developed a hand rotary broadcasting device for seeds, fertilizers and granular insecticides. Uniformity coefficient of distribution was determined for spreading urea using the broadcasting device and compared with that of a hand broadcasting process. The hand rotary broadcasting device was capable of spreading the materials over three to four times the urea that could be covered by the hand broadcasting process. The device could spread urea at a field coverage of 1.26 ha/h in paddy. Seeds such as paddy, gingelly, sorghum and other minor millets could be broadcast by the device.

2.3 Seed metering mechanism

Different metering mechanisms are used to meter seeds for planting, depending on the characteristics of the seed and the spacing desired. Metering mechanism in common use are as follows.

2.3.1 Agitator over adjustable orifice

This feed is used primarily with small seeds which cannot be selected singly. The hopper bottom plate has a circle of holes of different sizes, any of which can be fixed in delivery position to vary the rate (Fig.4a). An agitator is placed over the hole to prevent bridging of seeds in front of holes.

2.3.2 Fluted roller or external force feed

This feed is one of the oldest and most widely used device for bulk seed metering. It consists of a fluted roller rotating about a horizontal axis. The seeds are carried under cylinder and discharged about 45° past bottom centre into a delivery tube leading to the furrow opener as shown in Fig.4 b. The primary adjustment for seed rate is by sliding the entire feed shaft sideways to vary the length of fluted cylinder exposed to the seed. The delivery gate opening can be adjusted to several positions according to seed size and in some cases the speed of rotation can be varied by changing the sprockets. It is simple and easily adjusted with acceptable accuracy and uniformity of distribution of small grains.

2.3.3 Double run or internal force feed

This mechanism for grain drill consists of a wheel for each row. This double run wheel separates the cup into two

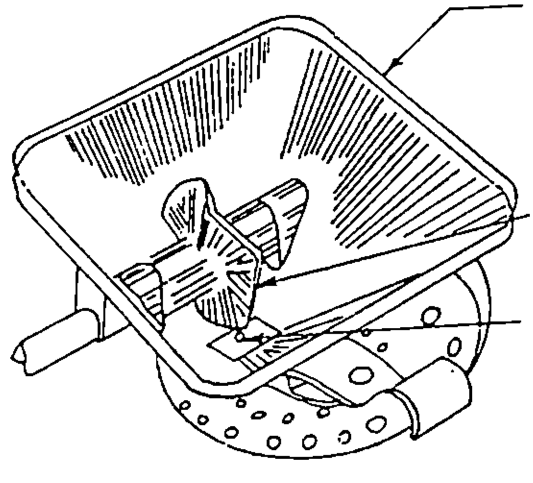


FIG.4a AGITATOR OVER ADJUSTABLE ORIFICE

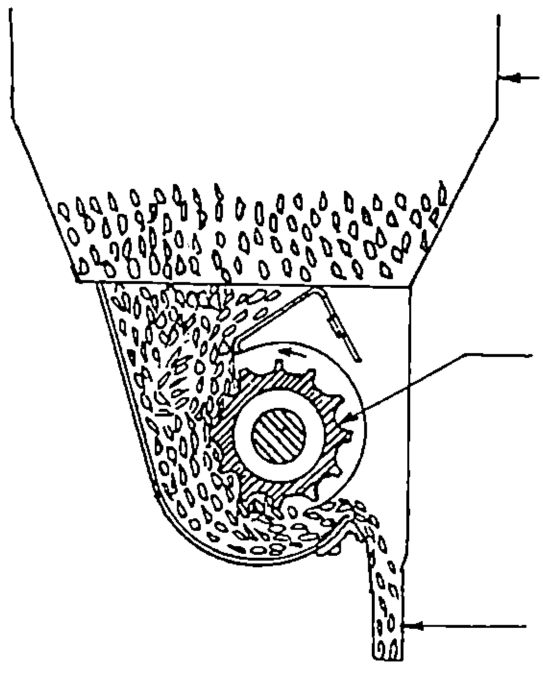


FIG.4b FLUTED ROLLER OR EXTERNAL FORCE FEED

(Gite et al., 1981)

parts. Each one of them will handle different seed sizes. The rimmed wheel has a shallow side and a deep side. The shallow side has small ribs on the inner edge of the rim. The deep side of the wheel has coarse ribs in the inner part of the rim. The shallow side is used for small seeds whereas coarser side is used for large seeds. When one of the sides is being used, the seed is prevented from flowing through the other side by using a special cover (Fig.5 a).

2.3.4 Cup feed

A series of cups on the rim of a vertical rotating wheel dip into a shallow pool of seed, lifting a few at a time and carrying them over top, where they drop into a delivery channel as shown in Fig.5 b. Rate of seeding is controlled by wheel speed. There is no restricted gate area through which the seed must pass, thus eliminating a possible source of seed cracking and damage. The accuracy of this type of feed is adversely affected by tilt of the hopper and jarring over rough ground.

2.3.5 Horizontal seed plate

This is the most popular mechanism where accuracy requirements dictate single seed selection. A horizontal seed plate contains shaped cells indented in the edge or a circle of round hole cells. The cells normally fill with one seed each

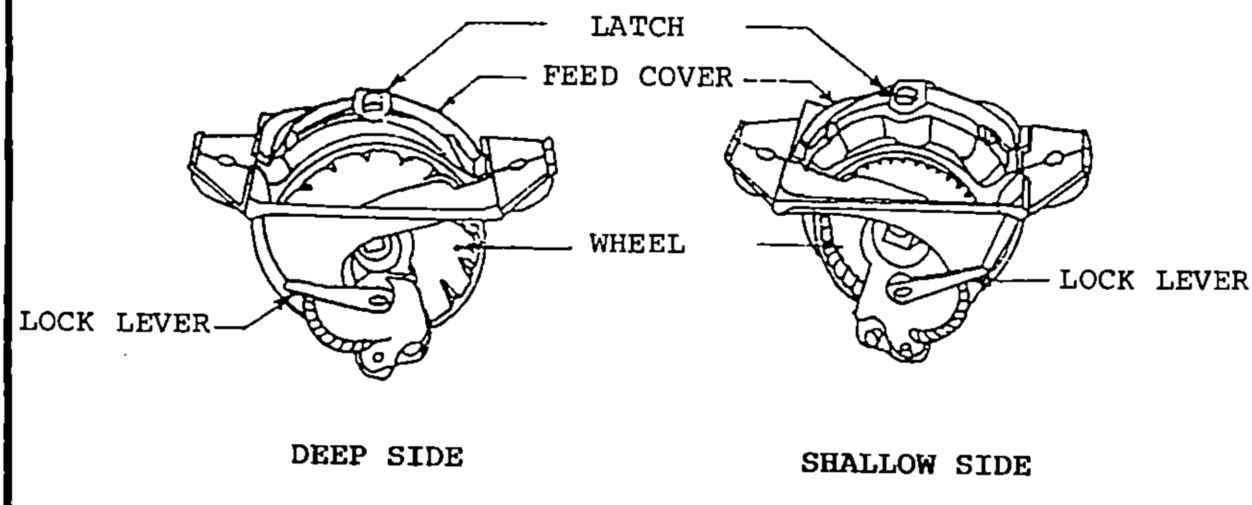


FIG.5a DOUBLE RUN OR INTERNAL FORCE FEED

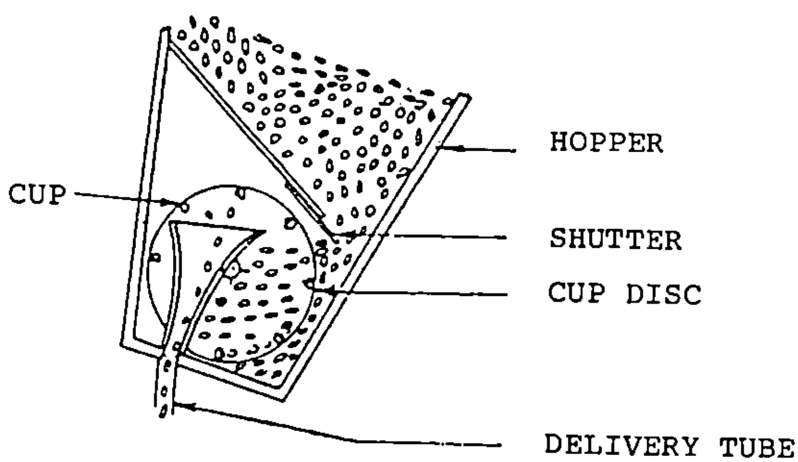


FIG.5b CUP FEED

(Gite *et al.*, 1981)

and pass over a cut off which stops additional seeds. The cell passes over the discharge spout, and a positive knock out is used to ensure the seed dropping out of the cell. The general arrangement is shown in Fig.6 a.

2.3.6 Inclined seed plate

This is a variation of the cup feed. An inclined seed plate with indented cells in the edge dips into a well of seed fed under a baffle plate from the hopper, lifts the seeds and drops them into a delivery tube as shown in Fig.6 b. This type of feed requires no cut off which otherwise causes seed injury, but it is affected by hopper tilt and rough ground. Speed of rotation must be slow to avoid centrifugal forces which throw the seeds from the cells prematurely.

2.3.7 Vertical seed plate

A vertical plate containing cells large enough for single seeds has the upper portion of the rim passing through the bottom of the hopper, where the cells fill with seed and pass out under a positive cut off. The seeds are ejected from the cells at the bottom of the wheel by a positive knock out. One type, shown in Fig.7 a, has a circumferential groove passing through the cells which allows a thin ejector plate to run in the groove at the discharge point.

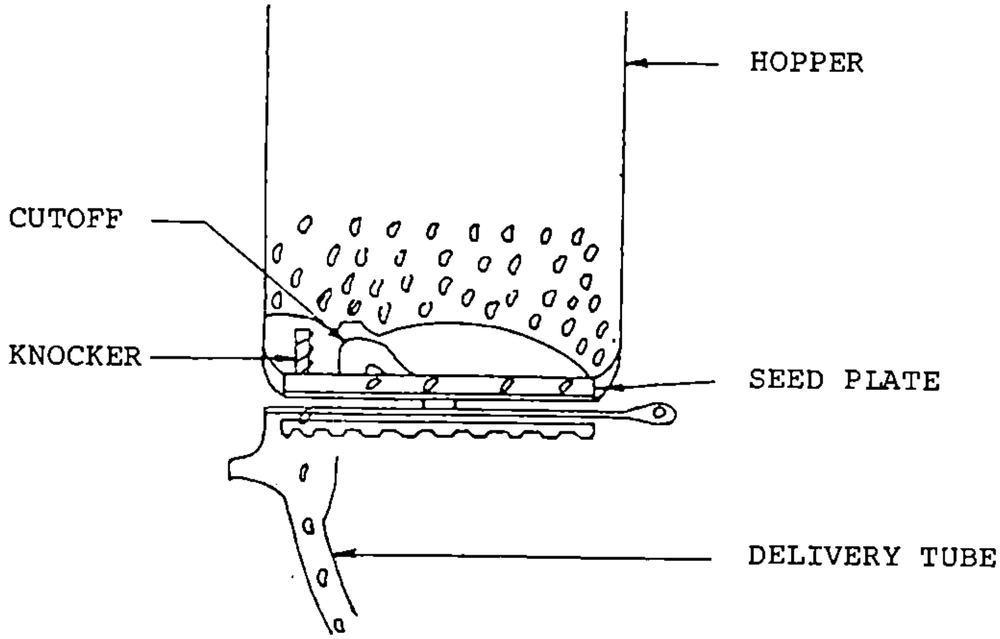


FIG.6a HORIZONTAL SEED PLATE

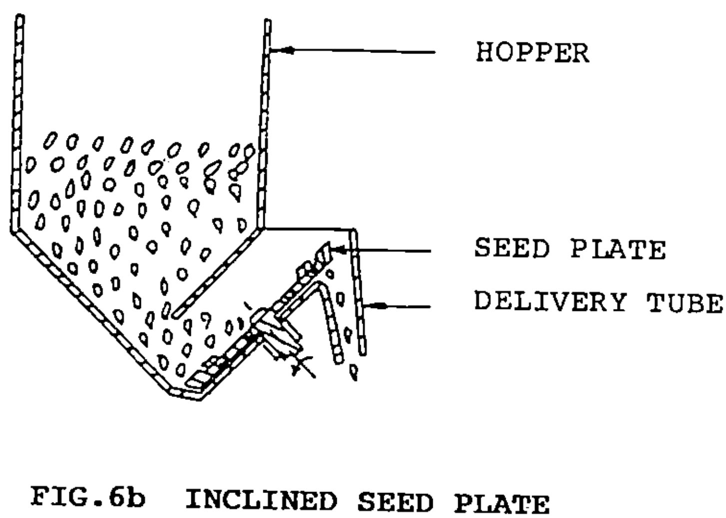


FIG.6b INCLINED SEED PLATE

(Gite et al., 1981)

2.3.8 Picker wheel feed

It is a feeding mechanism for automatic potato planter. It has cam actuated jaws which close to grasp seed piece while passing through the seed hopper and release it into the boot on opposite side. The arrangement is shown in Fig.7 b.

2.3.9 Single cell belt feed

This feed has been used experimentally for high speed planting of easily damaged peanuts. It carries seeds up an incline out of a well by holes in an endless belt, with a retainer belt used to hold the seeds in place until they are discharged downward into the furrow. This arrangement has the gentle handling characteristics of the inclined plate without being affected by jarring or high speed, plus the advantage of positive downward throwing of the seed into the furrow. The belt feed mechanism is shown in Fig.8.

2.3.10 Development of seed metering mechanism.

Bainer (1947) studied the effect of rim speed and size of cups on cell fill and found that a rim speed of 33 rpm gave 100 per cent space fill. He also reported that the cup size should be 164 inch larger than the diameter of seed and depth should be slightly larger than the diameter or thickness of seed and the cup of 12° wedge angle was found to be preferable.

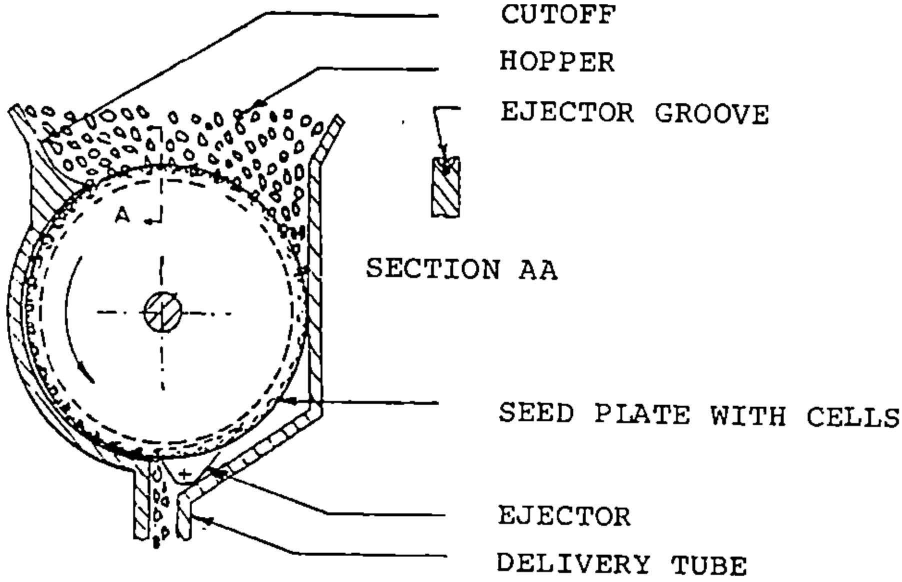


FIG.7a VERTICAL SEED PLATE

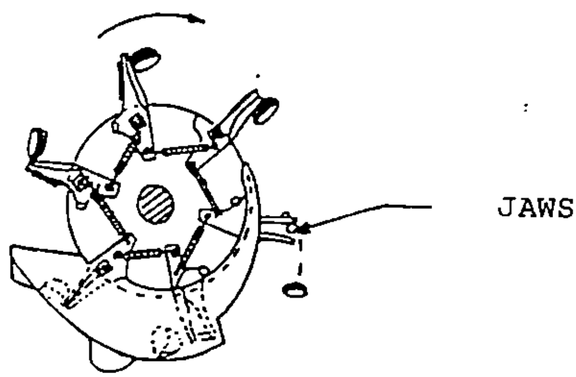


FIG.7b PICKER WHEEL FEED

(Gite <u>et</u> <u>al</u>., 1981)

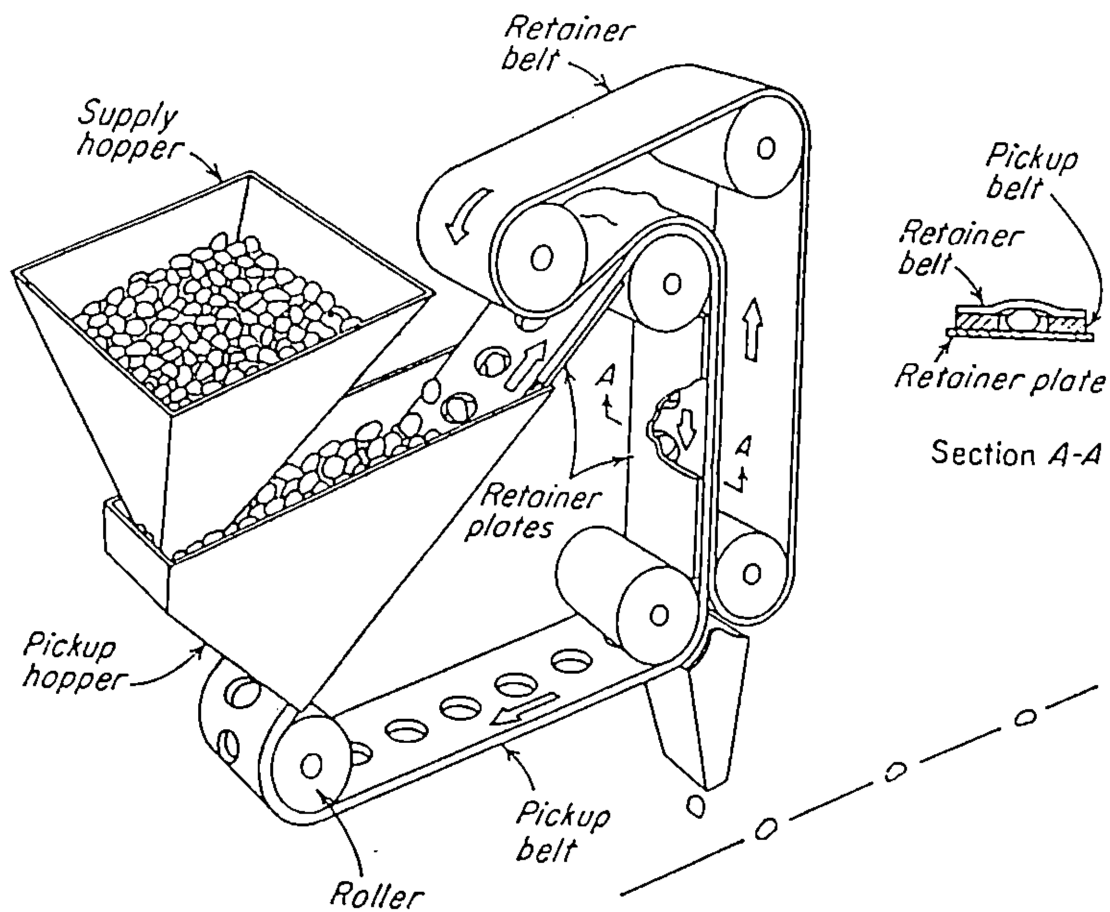


FIG.8 BELT FEED MECHANISM (Richy <u>et</u> <u>al</u>., 1961)

Barrington *et al*. (1948) studied the effect of various factors on seed metering and seed placement errors and found that they were influenced by variation in seed size and shape, planting speed, metering mechanism, seed hopper design, level of seed in the hopper, condition of soil furrow into which seeds are dropped, etc.

Futral *et al*. (1951) developed a belt feed seed metering mechanism in a high speed planter. A belt perforated by properly sized holes run at a 45° angle through the hopper. Seeds fall into the holes and were carried up and out of the hopper. Near the top of the belt path a soft rubber retaining belt contacts the seed belt and presses against it during the vertical descent, thereby holding the seed in place until the belts separate at the bottom. The action of the seed belt in changing from a vertical to a horizontal imparts to the seed a positive downward velocity resulting in them being thrown to the ground.

Levin (1964) made studies on simultaneous sowing of maize and beans using a truncated cone at the bottom of the seed container dividing the beans outside from the maize with standard cell feed discs having enlarged peripheral openings for beans and maize.

Short *et al*. (1970) developed a planetary vacuum seed metering device. It was a seed metering device with a zero nozzle velocity relative to the seed at pick up time and consists of two sprockets and a double chain. The small sprocket was designed to rotate inside the rigid mounted large sprocket chain assembly. The nozzles were placed at the pitch radius of the large sprocket. The nozzle was allowed to be, forced into the seed bed by a cam and the seed was released by removing the vacuum on the nozzle at the discharge point. Tests showed that the per cent of theoretical drop was almost independent of operating speed. Orifice air velocity was a critical factor in picking up one seed at a time. In one of the test, nozzles, delivering seeds at rates from 1½ to 6 seeds per second, had one seed attached for 80 per cent of the time and two seeds attached for 20 per cent of the time. The test was done for the cucumber seeds.

Rohrbach et al. (1972) worked on methods of monitoring and controlling metering accuracy and developed a fluidic seed metering unit which apparently had potential for sensing individual seeds and compensating for miss. The development of compensating for miss was considered as a recent development.

Rogers (1977) developed a supersonic seed metering device. In this device the seeds were introduced into a supersonic air stream and allowed to accelerate to supersonic speed would penetrate completely into the soil and be themselves

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unaffected to the extent that they would germinate and grow in the normal way. A number of advantages were as follows.

1. Seed could be sown through an existing crop or vegetation.
2. The need for preliminary cultivation would be removed.
3. Seed would penetrate into the soil where it would be protected to some extent from surface drying and some predators.

Davis (1980) developed a seed metering mechanism of unusual design which claimed to offer simplicity, infinitely variable seed drop rates and few moving parts. Seed from hopper drops on to rotating rollers round three of its sides so that the seed may exit from only the remaining side.

Rademacher (1981) did experiments on seed damage in grain augers and found that the damaging factors were shearing and jamming of seeds against the casing or wall.

Shafii et al. (1990) investigated metering of seeds by an air-jet flowing through a conical cavity. Special balls of various diameters were used to represent seeds. Pressure distribution and forces exerted on the ball were measured for different cone configurations, orifice diameters and cone ball clearances.

Shearer and Homes (1991) introduced a new concept of pneumatic metering using a submerged turbulent air-jet directed at a porous barrier. As the air-jet passed through the seed mass, individual seeds were picked up and held against the barrier. When metering sized seed corn with a vertical plate system, a 1.6 mm jet nozzle and supply pressure (gauge) of 30 to 40 kpa, theoretical drops of approximately 100 per cent were achieved. Similarly, 100 per cent theoretical drops were possible for individual soyabeans at supply pressure ranging from 20 to 25 kpa.

2.4 Furrow opener

Furrow opener may place the seed at the desired depth with minimum dispersion. The types most commonly used are as follows.

2.4.1 Hoe or shovel opener

It is most probably the oldest type of furrow opener. It consists of a narrow pointed shovel followed by a delivery boot.

2.4.2 Shoe opener

It is also called runner or sword opener and works well in poorly prepared seed beds. A wedge shaped blade opens the soil enough for the boot at the rear to deposite the seed. The sharp edge cuts through clods and sod, although it does not cut trash well. It opens the soil for receiving the seed with a minimum of disturbance and draft. The notch just behind the bottom portion of the sword allows moist soil to cover the seed before the dry upper soil closes over it.

2.4.3 Single-disc opener

It is very popular for grain drills since it cuts trash and penetrates well. A seed delivery boot drops the seed just behind the concave disc where it is covered by moist soil. A scraper for the convex portion of the disc is attached. A scraper may also be used on the concave side of the disc so as to reduce excessive throwing of soil at high speeds as well as to prevent soil build up.

2.4.4 Double-disc opener

Here the disc blades are straight rather than concave as with single disc opener. For deeper planting the delivery boot extends to the ground at the rear of the discs. The double-disc opener does not cut trash as well as the single-disc, but has a more positive furrow opening action in rough seed beds and because of the use of flat in stead of concave discs, does not throw excessive amount of soil at high speeds.

2.4.5 Wheel opener

It consists of a wheel with V-shaped rim which presses groove in the soil for placement of seed.

2.4.6 Development of furrow opener

Shukla _et al_. (1984) developed a coulter attachment which was fitted in a straight line in front of each furrow opener of a seed cum fertilizer drill and they had the provision to change the disc angle from 0 to 23°. This drill with coulter attachment was used for directly drilling wheat in no tilled and tilled fields. The yield of the wheat from different fields was recorded to compare the effect of different tillage system. The no-till field gave equal or better yield in most of the cases.

Dubey and Srivastava (1984) evaluated six types of furrow openers under black soil condition to identify the most suitable one. Shoe type furrow opener was found most suitable, both under dry and wet soil conditions, without much disturbance of soil. The design of this furrow opener was improved in terms of penetration and clogging in wet soil. To overcome the problem of clogging, the bottom of the opener was closed and delivery of seed and fertilizer was from back side. An extended plate between the two compartments avoids mixing of seed and fertilizer in the furrow. It was observed that in rough, cloddy and trashy conditions 150 mm shoe length and above were better.

Srivastava and Panwar (1986) conducted a study to evaluate the design parameters of furrow openers for use with pregerminated paddy seeders in puddled soil. Optimum depth of placement of seed, optimum width of furrow opener for proper seed placement and coverage and shape of furrow opener for minimum pull and soil recovery in the furrows were evaluated. The optimum depth of seed placement was observed to be 2 cm. Furrows upto 4 cm width and 2 cm or more depth recovered fully their level with soil having moisture content of 25.7 per cent or more. Horizontal furrow openers with 90° sweep angle and 45° approach angle caused minimum pull and complete soil recovery in furrow of 4 cm width and 2 cm depth.

Development of a furrow opener and seed coverer for a direct sowing drill for paddy was done by Nakamura (1987). The furrow opening blade was tapered with a downwardly sloping upper surface covered with an overhanging plate of similar shape and horizontal lower surface covered upwards at the end, like a knife. In most of the cases, the seed depth was greater than the depth of the furrow opening blade. And also the depth varied with respect to the firmness of the soil.

2.5 Testing of sowing machines

Patterson (1963) described a detailed test procedure for sowing machines. Indoor test rig included stationary calibration, assessment of seed damage, segregation and spacings, the latter using both sand bed and sticky belt method. Field testing was carried out to assess the quality and rate of work, ease of operation and adjustment and suitability of construction.

CIAE (1979) has prepared a test code for testing and evaluation of planting machine based on the Indian standard test code (IS: 6316-1971) and test codes followed by different ICAR sponsored organisations. The test code is briefly described as follows:

2.5.1 Laboratory test

2.5.1.1 Seed metering

1. Calibration

The step by step procedure for calibration of seed drill as follows:

a. Theoretically determine the number of revolutions of the ground wheel to cover a convenient fraction of a hectare.

b. The drill should be jacked up and small bags should be tied up to each furrow opener. The ground drive wheel should be turned manually at the working speed for the specified number of revolutions with selected seed in the hopper.

c. The seeds dropped and collected in the bags are weighed. The seed rate is noted for the area covered by the specified revolutions of the wheel and the seed rate for one hectare is calculated and expressed in kg/ha.

2. Mechanical damage

From each of the seed tubes, sample should be taken and number of damaged seeds should be recorded. Calculate the percentage of damaged seeds.

2.5.1.2 Seeding uniformity

Two methods. Sand bed method and Sticky belt method.

2.5.1.2.1 Sand bed method

Prepare a sand bed, adjust furrow openers for zero depth of cut, fill the seed hopper with specific quantity of seed and run the drill over the bed at designed speed. The number of seeds dropped and the spacing between them are noted down.

2.5.2 Field tests

2.5.2.1 Power requirement

a. Draft should be measured by a suitable tension dynamometer at normal working speed. If force is measured at an angle to the ground, the horizontal component should be calculated.

b. Speed of operation should be measured. For this a minimum distance of 30 m may be marked and the time taken to cover the distance may be recorded by a stop watch. This should be repeated for atleast three times.

c. Compute the power as follows:

$$\text{Power} = \frac{\text{Draft in kg} \times \text{speed in m/s}}{75}$$

2.5.2.2 Field efficiency and labour requirement

Field efficiency is the ratio of effective field capacity to the theoretical field capacity. The effective field capacity is the actual average rate of coverage including time lost in filling hoppers, turning at head lands, unclogging the openers, making adjustments and so on. The theoretical field capacity is the rate of field coverage that would be obtained if the drill operates without interruption.

$$\text{Theoretical field capacity} = \frac{W \times S}{10}$$

where,

W = width of seed drill in m

S = speed in kmph

2.5.2.3 Assessing the ease of operation

Quantitative assessment is done for the ease of operation of the drill.

2.5.2.4 Suitability and soundness of construction

The drill should be operated for continuous field work for atleast four hours. Tests should be conducted atleast at three locations.

Materials and Methods

MATERIALS AND METHODS

The development and selection of individual components of the dibbler and the experimental programme are presented in this chapter.

3.1 Functional requirements

The functional requirements of the manually operated paddy dibbler are given below.

3.1.1 K.A.U. specifications

As per the Package of Practices Recommendations of Kerala Agricultural University (1986) the following specifications are drawn:

(i)	Row to row spacing	-	15 cm
(ii)	Hill to hill spacing	-	10 cm
(iii)	Number of seeds/hill	-	4-6
(iv)	Seed rate	-	80-90 kg/ha

3.1.2 Other specifications

(i) The equipment should be able to operate in the field manually at a forward speed of 0.7 kmph.

(ii) The number of rows has been decided to be fixed as three so that the unit with seed can be operated by one man.

(iii) The number of components should be the least for higher reliability, easy manoeuvrability and maintenance by the farmers.

(iv) The components should be fabricated and assembled locally with readily available materials from the local market.

(v) It should be repairable by local artisans.

(vi) The cost should be within the limit so that a small farmer can own a unit.

3.2 Functional components of the equipment

In order to achieve the above functional requirements, a three row manually operated dibbler was developed. It consists of the following parts: Seed box, roller with metering mechanism, seed tube with furrow opener, frame, handles and marker. Details of the machine is shown in Fig.9.

3.2.1 Seed box

Seed box serves as a storage space for seed material. The box must have an optimum capacity, and must feed seeds uniformly.

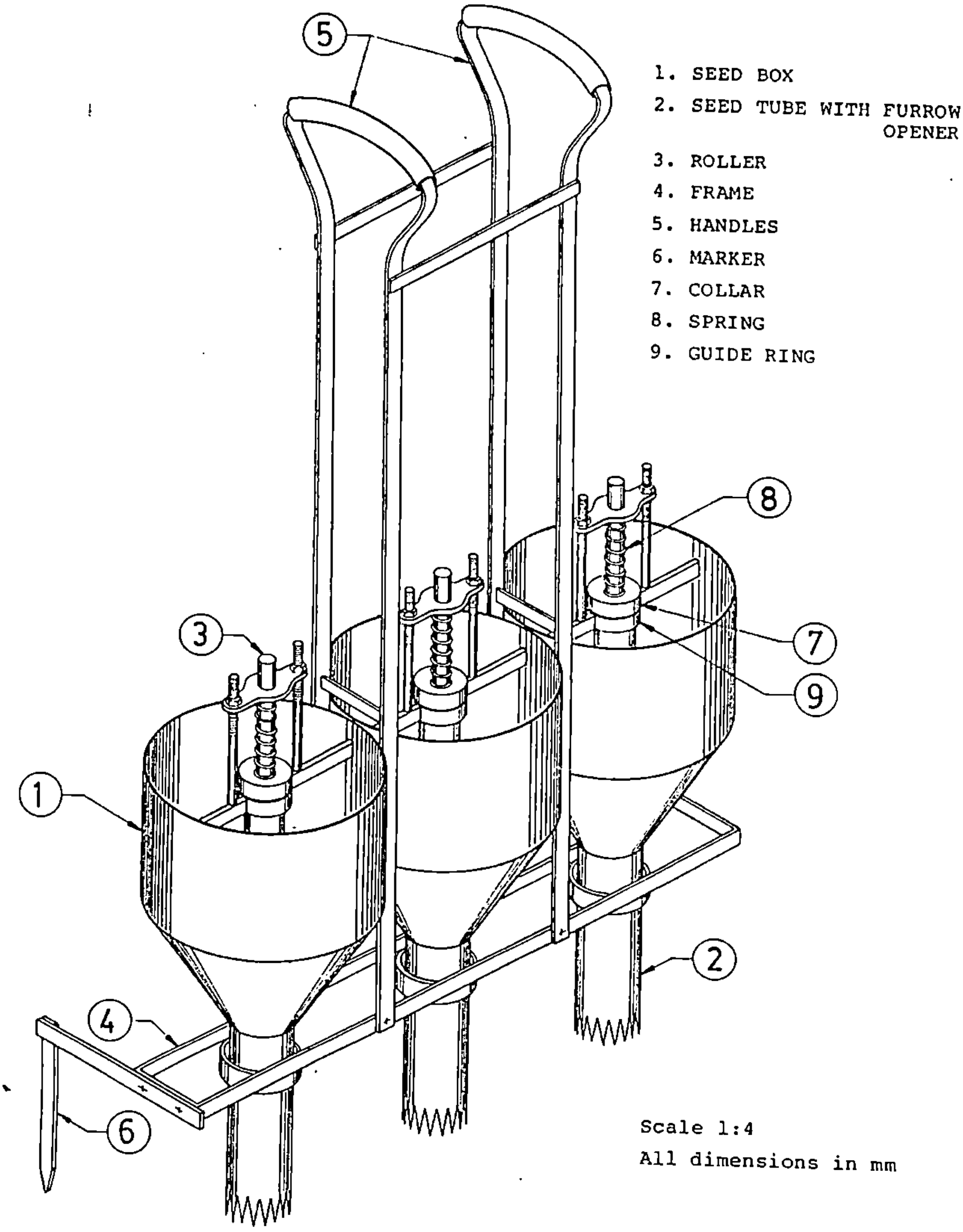


Fig. 9 PADDY DIBBLER (an isometric view)

It was decided that the seed box should store seed for one and a half hours of operation without refilling the box so that the area of coverage is about 0.05 hectare. Thus 20 times filling of the box is needed for one hectare of land. Accordingly the capacity of one seed box was found out by using the equation given below.

$$Q = \frac{T.W.V.R.}{N.D.} \quad \text{(John, 1989)}$$

Q = Capacity of the seed box

T = Time between two consecutive fillings

W = Width of the dibbler in metre

V = Speed of operation in metre per hour

R = Seed rate in kg/sq metre

N = Number of seed boxes

D = Density of seed in kg/m^3

$$Q = \frac{1.5 \times 0.45 \times 0.7 \times 1000 \times 85/10^4}{3 \times 800}$$

$$= 1674 \text{ cc}$$

The capacity thus obtained was 1674 cc. Since the density of paddy is 0.8 gm/cc, 1.34 kg of paddy occupies a volume of 1674 cc. Hence the total weight of seeds carried in three boxes was 4 kg.

In order to avoid the spilling of seeds from the box during the operation, a clearance of 2.5 cm was provided at the top of the box. To accommodate the roller and its fixing accessories like springs, etc. an additional volume was required.

Considering all the above aspects the volume of the seed box was fixed as 2000 cc.

The seed box was fabricated with mild steel sheet of 22 gauge. The top of the seed box was made circular with a diameter of 150 mm, and a height of 100 mm, of which 75 mm could be used for storage of seed. Thus the top of the seed box contained a volume of 1325 cc. The bottom of the seed box was made as truncated cone of height 100 mm. It was set at an angle to the base equal to the angle of repose of paddy which ensure free flow of seeds. As the height of the truncated cone was 100 mm, the bottom portion of the seed box contained a volume of 698 cc. Hence the total volume of the top and bottom portion of the seed box was 2023 cc which is the desired volume. A hole of 24.5 mm diameter was provided at the bottom of the box for occupying the roller type metering mechanism. A light tension spring was provided around the upper stem of the roller which acts against the soil pressure while working in the field (Plate 1). The spring was held tight by suitable screws (Plate 2).

Three such boxes were fabricated and fitted to the frame (Fig.10). The details of the seed box is shown in Fig.11.

Plate 1 Manually operated three row paddy dibbler

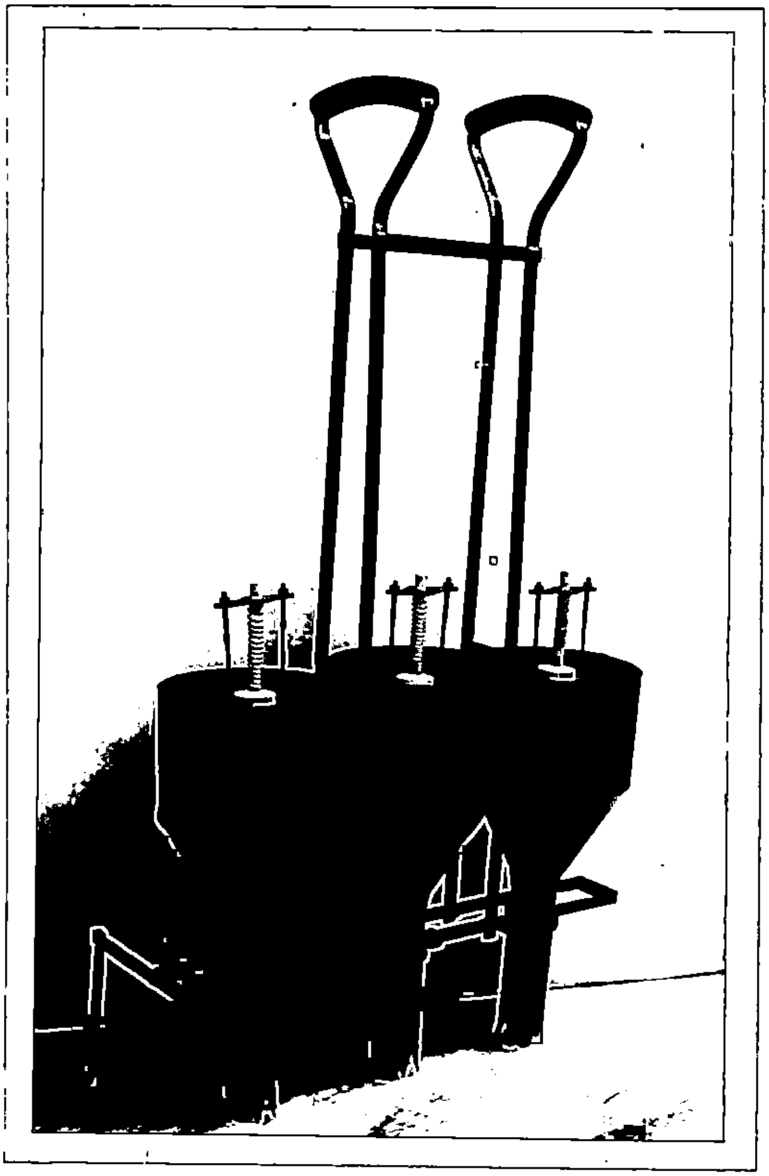
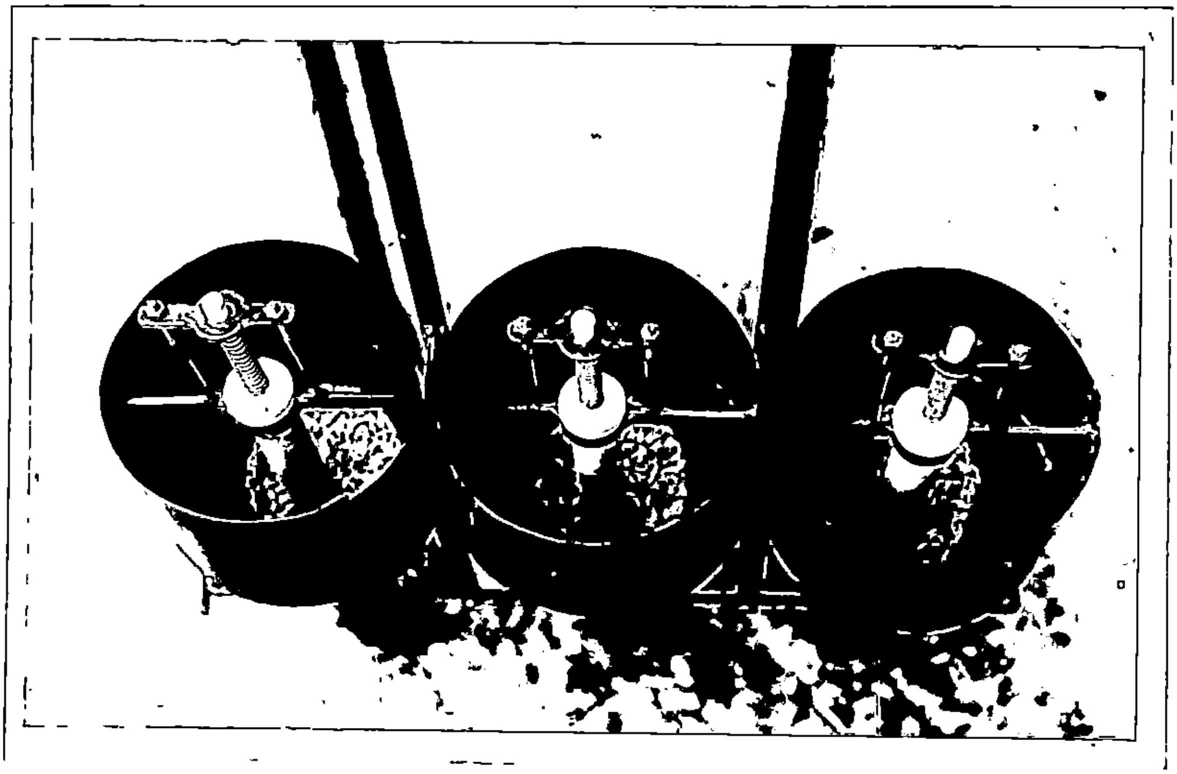


Plate 2 Hopper and roller with spring tension adjusting mechanism



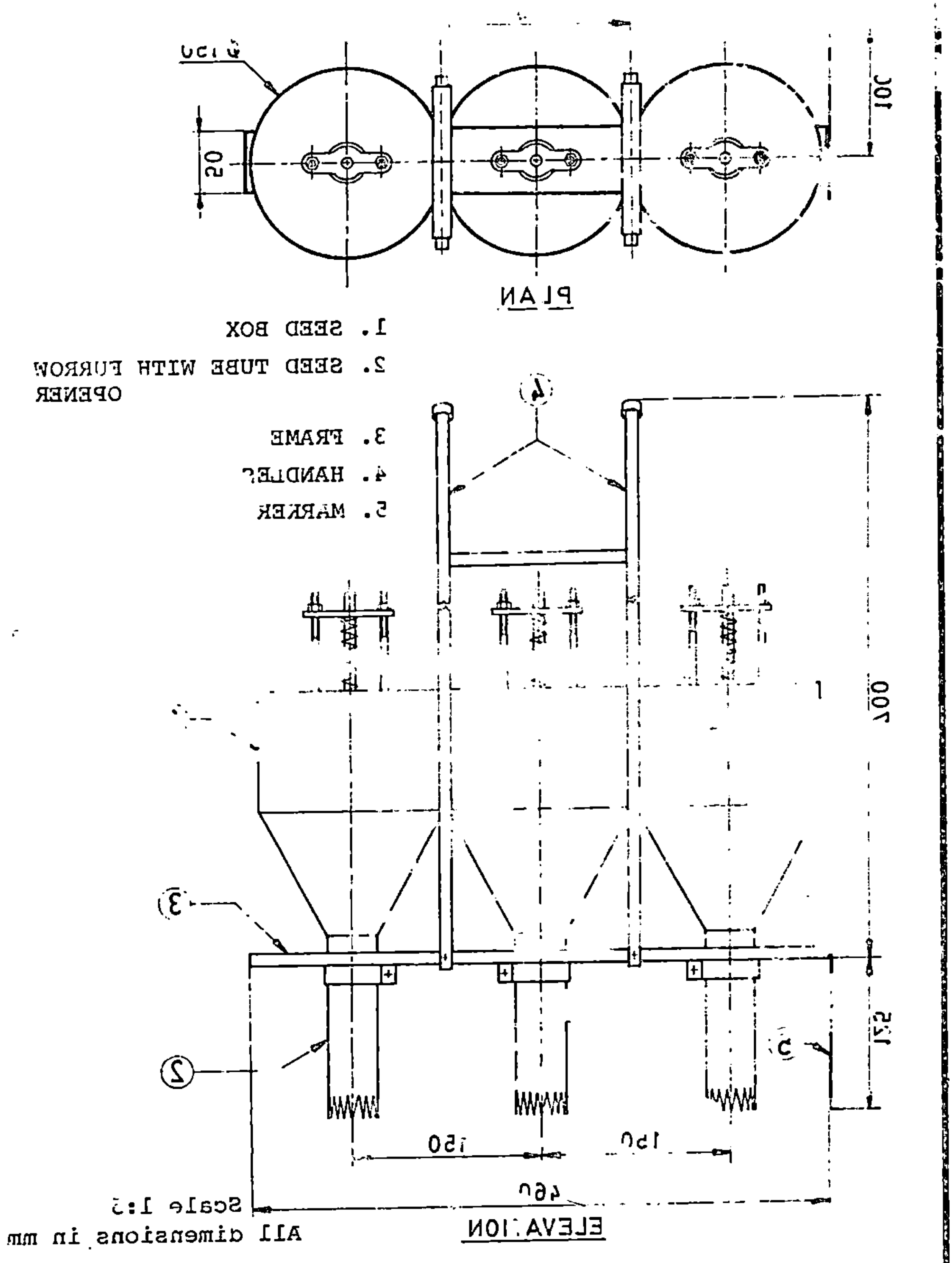
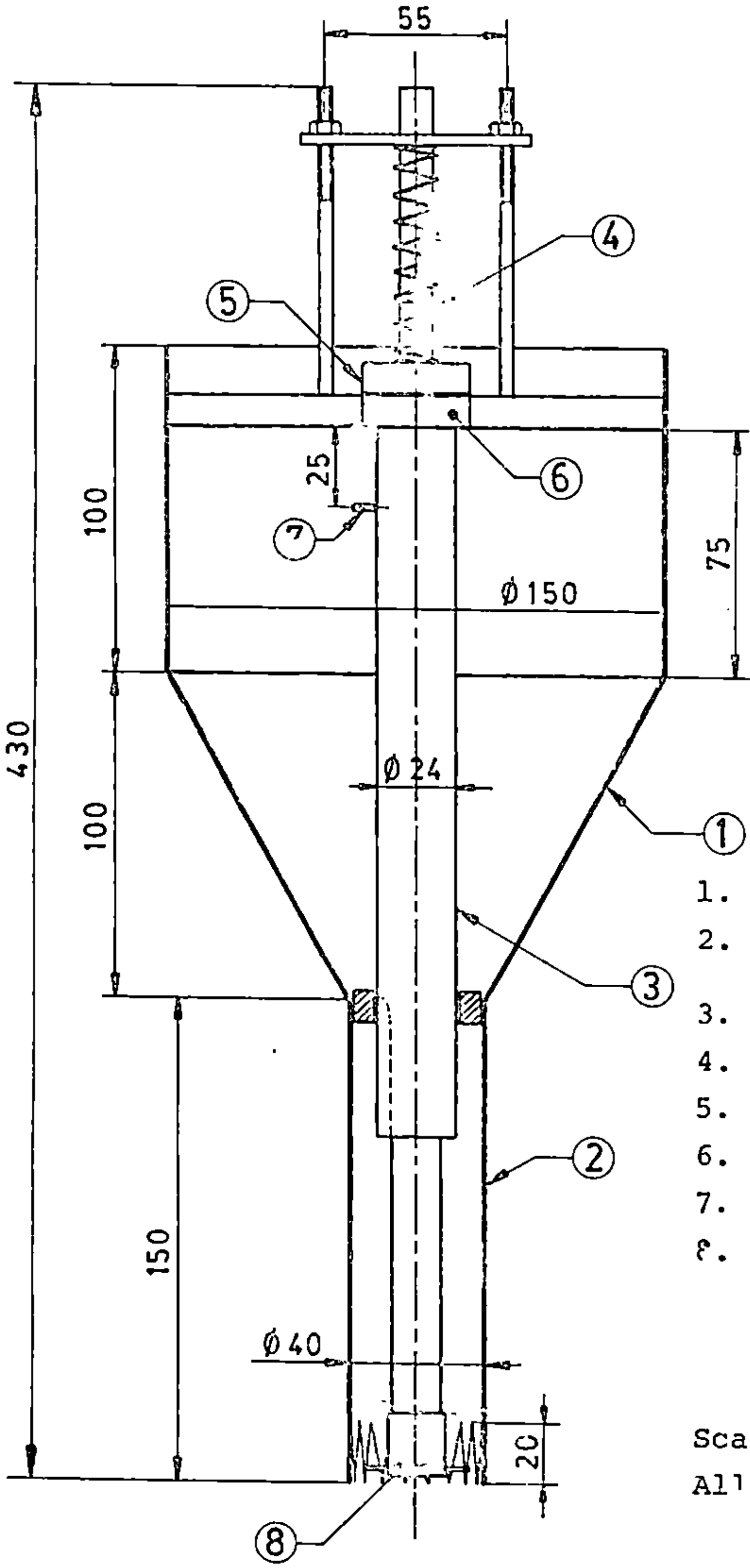


Fig.10 PADDY DIBBLER



1. SEED BOX
2. SEED TUBE WITH FURROW OPENER
3. ROLLER
4. SPRING
5. COLLAR
6. GUIDE RING
7. STOPPER
8. NON CLOGGING COLLAR

Scale 1:2
All dimensions in mm

Fig. 11 SECTIONAL VIEW OF SEED BOX WITH ROLLER

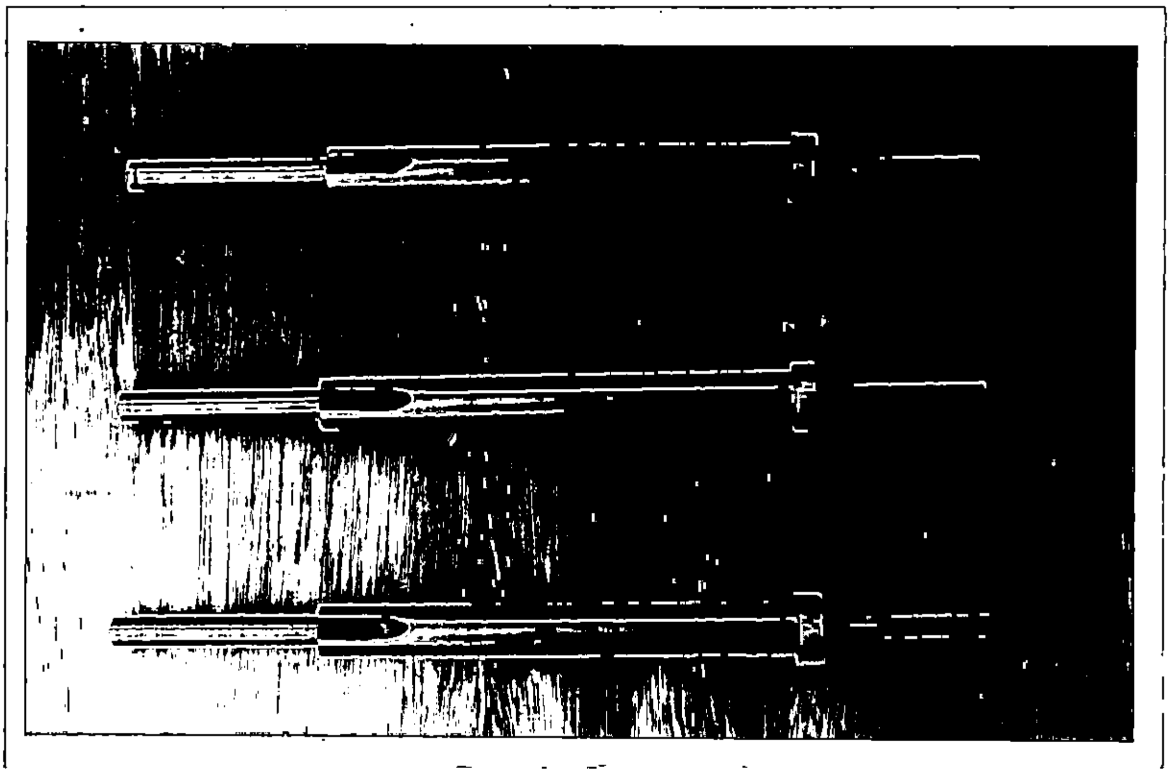
3.2.2 Roller

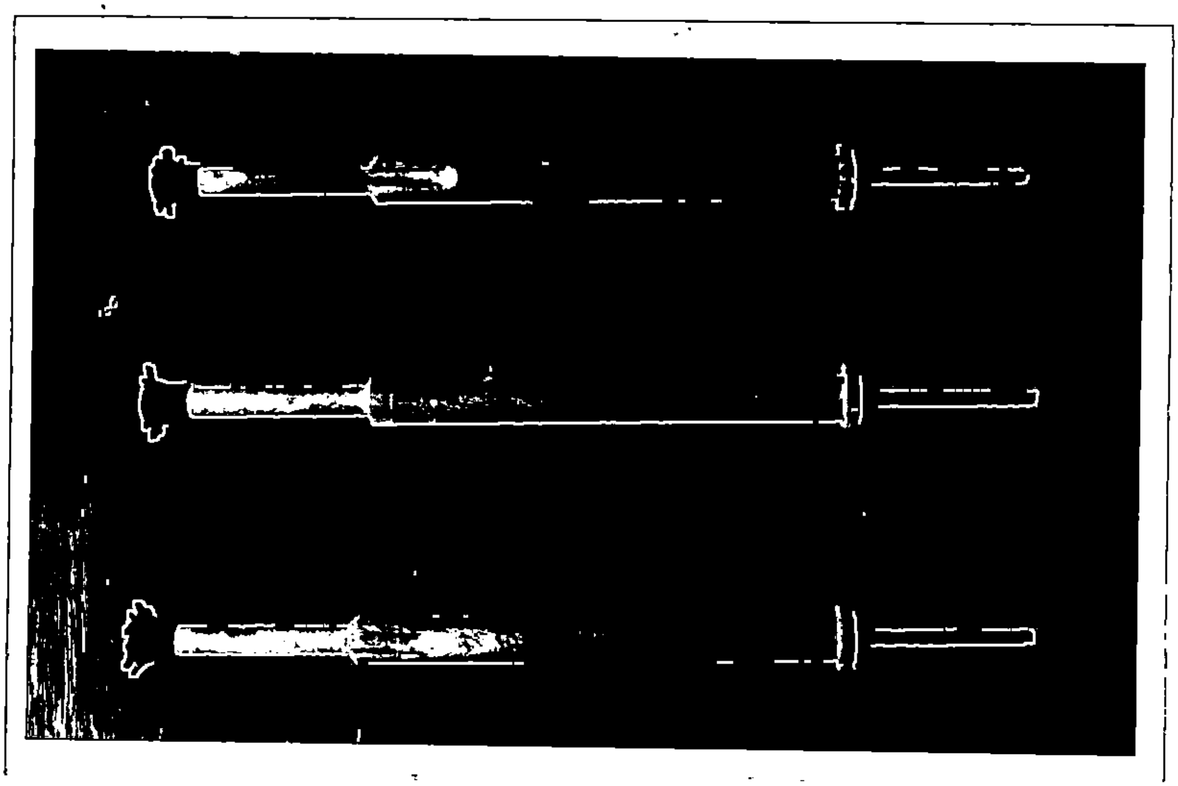
The roller was passed through the centre of the seed box vertically. Each seed box had its own individual roller. At first the roller of mild steel was selected (Plate 3). But while testing with mild steel roller the number of damaged seeds were found to be more. So it was replaced by a wooden roller, where the number of damaged seeds were less (Plate 4).

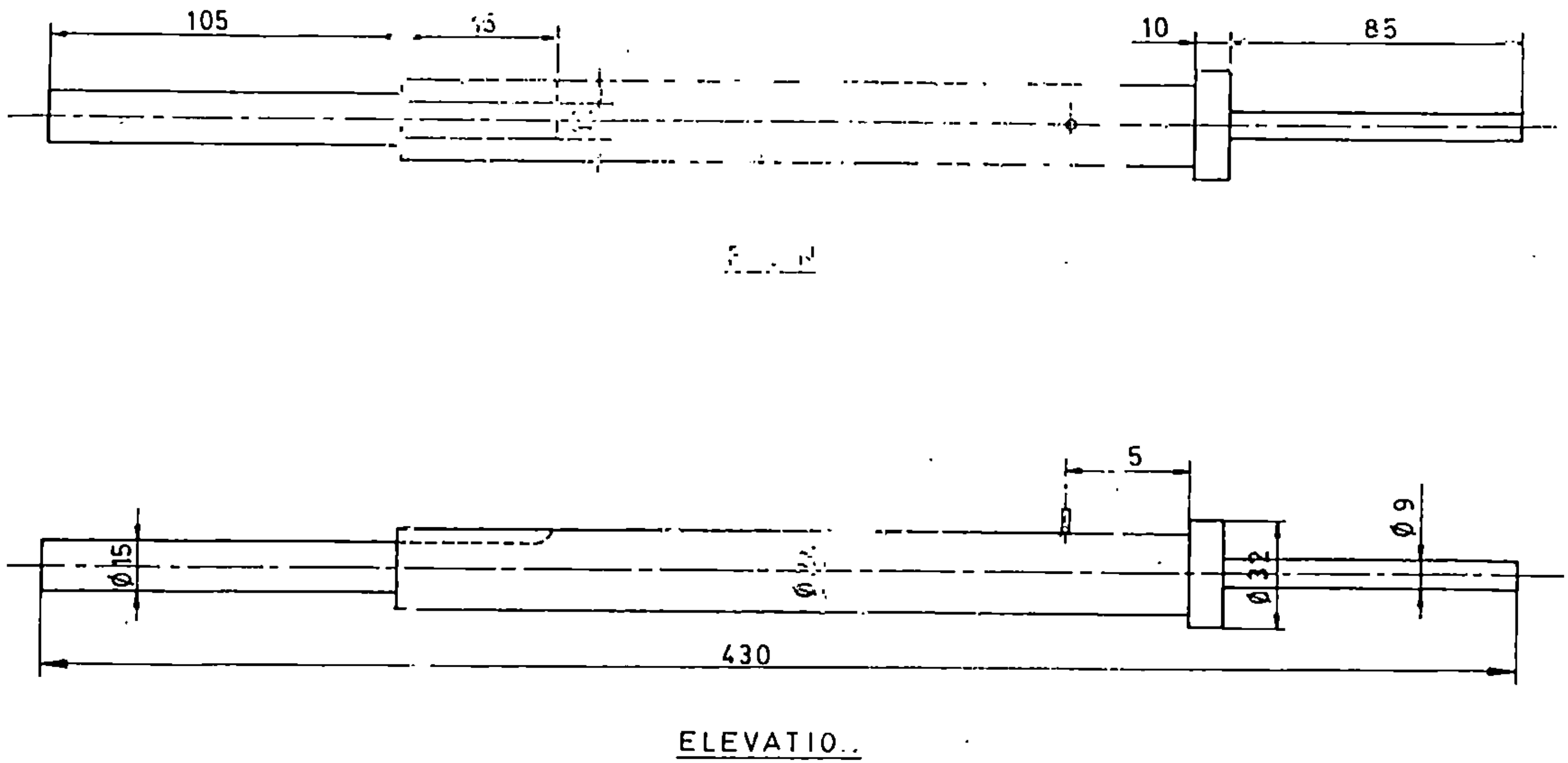
The overall length of the roller was 430 mm. The diameter of the roller at the top was 9 mm to a length of 85 mm. This was for the provision of the spring around it. Then the diameter was changed to 24 mm to a length of 230 mm. A vertical slot of 45 mm length and 11 mm width was provided at the bottom of the latter portion for metering the seeds. At resting condition the vertical slot remains inside the seed tube, while rest of the portion of this section would remain inside the seed box. A collar of diameter 32 mm was provided at the top of this portion of 230 mm length so that the complete roller would not slip down due to the spring action at the top. For the easy vertical movement of the roller a ring guide was also provided at the top of the seed box. On this ring the roller would rest with the help of the collar. The diameter of the remaining portion of the roller was 15 mm with a length of 105 mm. This portion would remain inside the seed tube. The position of the roller inside the seed box is shown in Fig.11 and the dimensions of the roller is shown in Fig.12.

Plate 3 Mild steel roller with metering groove

Plate 4 Wooden roller with nonclogging collar attachment







Scale - 1:2
All dimensions in mm.

Fig. 12 ROLLER

In order to avoid the clogging of the space in between the roller stem and the furrow opener of the seed tube with clods, a collar with spikes around the periphery was provided at the bottom of the lower stem of the roller (Plate 4).

3.2.3 Seed tube with furrow opener

The seed tube was used for guiding the seeds from the metering mechanism to the hole made by the furrow opener. The seed tube should have smooth walls to reduce bounce and may be of straight tube of minimum cross section.

The seed tube was made of mild steel sheet of 18 gauge. The overall length of the seed tube was 150 mm and the cross section was circular having a diameter of 40 mm. The length of the seed tube was fixed as 150 mm in such a way that the total height of the equipment would not affect the working capacity of an operator and the ease of his work. By providing a diameter of 40 mm, a clearance of 12.5 mm on either side of the roller inside the seed tube was obtained for free falling of seeds. A further increase in diameter would increase the dispersion of seeds. The seed tube was connected directly to the seed box which formed an integral part of the seed box (Plate 1).

The furrow opener was used for making the seed hole at the desired depth. There was no separate furrow opener in this equipment for making the hole. During the operation of the equipment, the roller and the seed tube were pushed into the soil. After a small downward travel, the roller was moved upwards due to the upward thrust of the compacted soil. The soil pressure was against the pressure of the spring provided at the top of the roller. The seed hole was created due to the downward travel of the roller and the seed tube for dropping the seeds. The end of the seed tube was made with serrations to a length of 20 mm. This helped the bottom of the seed tube to penetrate into the soil during the time of working. Thus the roller and the bottom of the seed tube together made a hole in the soil in which the seeds were dropped.

There was no covering device in this unit. When the dibbler was taken out from the soil the seeds would be covered with the surrounding soil.

3.2.4 Metering mechanism

Depending on the characteristics of the seed and the spacing desired, different metering mechanisms are used to meter seeds for planting.

The metering mechanism employed in this dibbler was unique in design and was different from other existing ones. A modified version of the roller type metering mechanism was used.

The roller was passed through the centre of the seed box vertically. The roller had a vertical slot of length 45 mm and a width of 11 mm. The length of the vertical slot could be adjusted by providing a stopper on the roller at a suitable point below the collar (Fig.11). The upward movement of the roller (stroke length) could be varied by varying the relative position of the stopper and the stationary guide ring of the roller. And the downward travel of the roller was limited by the provision of a fixed collar at the top. When the dibbler was pressed vertically downward, the roller would move upward by the soil pressure against the spring pressure. As the roller moved upward, the portion of the roller having the vertical slot would move from the seed tube to the seed box and thus would come in contact with seeds and the seeds were moved and carried to this slot. This would provide an easy path for the travel of the seed. When the equipment was taken out from the soil, the soil pressure on the roller was released and due to the spring pressure the roller moved downward and the seeds carried in the slot were released and fell through the seed tube by gravity into the soil.

3.2.5 Frame with handles

The frame must be as light as possible for easy operation and also for the reduced power input, but yet be strong enough to withstand all types of loads in working condition.

The length of the frame was 460 mm and width was 50 mm. It was selected in such a way that it accommodated three seed boxes at equal spacing of 150 mm and the two handles.

The handles were made of mild steel. The total length of the handle was 700 mm. The length of the handle was taken in such a way that the unit could be held and managed with the least possible effort by a single man (Plate 5). It should be light in weight, strong, smooth and comfortable to operate. The distance between the handles were 155 mm.

3.2.6 Marker

The mild steel marker was used for marking the hill to hill spacing. The spacing could be varied by varying the position of the screws of the marker.

3.3 Experimental programme

Various tests were conducted in the laboratory and in the field to evaluate the dibbler.

3.3.1 Laboratory test

3.3.1.1 Selection of stroke length

By varying the stroke length of the roller the length of the vertical slot coming in contact with seeds could be varied

Plate 5 Paddy dibbler in operation

This was achieved by changing the position of the stopper on the roller. For different selected stroke lengths the number of seeds dropped were noted. Then the stroke length was selected in such way that the number of seeds dropped were in the range of 4 to 6.

3.3.1.2 Calibration

For the checking of metering, a sand bed of 3.5 m length and 1.5 m width was prepared. The stroke length of the roller was so fixed that it would give the desired seed rate of 4 to 6 seeds/hill. The hopper was filled with a weighed amount of grains to the desired level. Then the above area was sown. After sowing, the weight of the remaining seeds were taken. The difference in weight divided by the area sown gives the rate of sowing. This process was repeated three times and average was taken as the seed rate in kg/ha.

3.3.1.3 Mechanical damage

After filling the hoppers with the seeds the metering mechanism was operated. Then samples from each seed tube were collected and the number of damaged seeds were noted by actual observation. The damage was represented in percentage This was done for both mild steel roller and wooden roller.

3.3.2 Field tests

3.3.2.1 Seeding uniformity

The seeding uniformity was studied by the method of sand bed test. A sand bed of 3 m length and 0.5 m width (effective width of the dibbler) was prepared. The hopper was filled with seeds and operated over the bed at 0.5 to 0.7 kmph. Seeds dropped per hill were noted.

3.3.2.2 Spacing uniformity

The spacing between hills could be achieved by using the marker on the frame. Hence spacing uniformity is not a machine factor and depends only on the efficiency of an operator.

3.3.2.3 Field capacity and field efficiency

To find the effective field capacity a plot size of 10 m x 10 m was selected and sown by the equipment. The time taken to cover the area was noted. The effective field capacity = Area covered/actual time. The theoretical field capacity was calculated using the equation $\frac{WS}{10}$ where w = width of seed drill in m, S = speed in kmph.

$$\therefore \text{Field efficiency, \%} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

3.3.2.4 Emergence count

Both sand bed test and field test were conducted.

3.3.2.4.1 Sand bed test

Two tray of size 60 x 38 cm was selected and planted with the dibbler. Seeds germinated per hill and the spacing between hills were taken to study the germination and spacing obtained between hills in sand bed condition.

To find the percentage losses of seeds after germination, the metering mechanism of the dibbler was operated 20 times with seeds in the hopper. The seeds were collected and germinated in a sand bed. The germinated seedlings were noted.

3.3.2.4.2 Experimental field test

An area of 3 m x 3 m was planted with the dibbler. Seeds germinated per hill and the spacing between hills were taken to study the germination and spacing obtained between hills in the field condition. The type of the soil was sandy loam.

3.3.2.4.3 Actual field test

An area of 10 m x 10 m was planted with the dibbler. Seeds germinated per hill and the spacing between hills were taken to study the germination and spacing obtained between hills in the field condition. The type of the soil was sandy loam with a greater proportion of laterite particles.

Results and Discussion

RESULTS AND DISCUSSION

The results of the laboratory and field studies conducted and also the economics of the paddy dibbler are presented in this chapter.

4.1 Laboratory test

4.1.1 Selection of stroke length

The results of the test conducted for the selection of stroke length is given in Table 1. The stroke length obtained was 25 mm so that the average number of seeds dropped were 5. The recommended number of seeds dropped are 4 to 6 per hill.

4.1.2 Calibration

The results of the test conducted for calibration is given in Table 2. The average seed rate obtained was 86 kg/ha. The recommended seed rate for dibbling is 80 to 90 kg/ha. The result showed that the seed rate obtained was within the recommended range.

4.1.3 Mechanical damage

The results of the test to find out the mechanical damage for both mild steel roller and wooden roller are

Table 1. Selection of stroke length of the roller

Test number	Number of seeds dropped from the seed tube		
	Stroke length (mm)		
	20	25	30
1	2	5	11
2	4	6	10
3	2	4	9
4	3	5	12
5	4	6	11
6	2	4	9
7	1	7	10
Average	2.57	5.30	10.28

Table 2. Calibration (Sand bed test)

Seed rate setting: 4 to 6 seeds/hill; Required seed rate: 80 to 90 kg/ha

Test number	Area covered			Initial weight of the seed	Weight of the seed after sowing	Difference in weight		Seed rate
	Width (m)	Length (m)	Area (m)	(g)	(g)	(g)	(kg)	(kg/ha)
1	1.5	3.5	0.000525	3000	2955.0	45.0	0.0450	85.71
2	1.5	3.5	0.000525	3000	2955.5	44.5	0.0445	84.76
3	1.5	3.5	0.000525	3000	2954.0	46.0	0.0460	87.62
Average								86.03

presented in Tables 3 and 4, respectively. The mechanical damage was 20.67 per cent for the mild steel roller. In order to reduce the percentage of damage, the mild steel roller was replaced by a wooden roller in which the mechanical damage was 4.84 per cent. Therefore the wooden roller was selected for fabrication. This also reduced the weight of the machine considerably.

4.2 Field test

4.2.1 Seeding uniformity

The number of seeds fallen per hill for three different speeds of operation conducted on sand bed are recorded in Tables 5 to 7. The uniformity of seeds dropped from each seed tube was analysed statistically at 5 per cent level of significance. It was found that the average number of seeds fallen per hill was 5, which is the average of the recommended rate of 4 to 6 seeds/hill. The calculation of checking the uniformity of seeds per hill from each seed tube at 0.5, 0.6 and 0.7 kmph is shown in Appendix I, II and III respectively.

The seeding uniformity was also analysed by coefficient of variation method, at 0.5, 0.6 and 0.7 kmph. The values of coefficient of variation obtained at the three speeds were 49.13 per cent, 49.22 per cent and 49.44 per cent respectively. The calculations of checking the uniformity of seeds dropping at

Table 3. Mechanical damage (Mild steel roller)

Kind of seed : Paddy Rate of setting : 4 to 6 seeds/hill

Variety of seed : Jyothi

Test number	Damage per cent from each seed tube			Average
	No.1	No.2	No.3	
1	18.18	25.00	23.00	22.06
2	20.00	16.66	19.04	18.57
3	21.40	20.00	22.22	21.20
4	17.39	21.40	17.64	18.81
5	23.80	21.73	16.66	20.73
6	22.22	20.00	18.75	20.32
7	25.00	21.05	23.00	23.02
Average	21.14	20.83	20.04	20.67

Table 4. Mechanical damage (Wooden roller)

Kind of seed : Paddy   Rate setting : 4 to 6 seeds/hill

Variety of seed : Jyothi

Test number	Damage per cent from each seed tube			Average
	No.1	No.2	No.3	
1	4.76	7.69	5.55	6.000
2	6.89	3.03	3.57	4.497
3	3.84	3.84	6.66	4.780
4	4.34	4.16	5.00	4.500
5	5.55	3.70	4.54	4.597
6	3.84	4.54	7.40	5.260
7	4.00	4.76	4.16	4.310
Average	4.74	4.53	5.26	4.840

Table 5. Seeding uniformity (Sand bed test)

Width of sand bed : 0.5 m

Length of sand bed : 3 m

Time taken : 21 second

Speed : 0.5 kmph

Sl.No.	Number of seeds fallen per hill from each seed tube		
	No.1	No.2	No.3
1	7	4	4
2	0	9	3
3	3	4	7
4	8	5	0
5	4	4	4
6	6	3	8
7	5	5	4

Table 6. Seeding uniformity (Sand bed test)

Width of sand bed : 0.5 m

Length of sand bed : 3 m

Time taken : 18 second

Speed : 0.6 kmph

Sl. No.	Number of seeds fallen per hill from each seed tube		
	No.1	No.2	No.3
1	4	8	3
2	5	4	3
3	0	6	5
4	3	8	4
5	8	2	6
6	2	4	4
7	11	7	8

Table 7. Seeding uniformity (Sand bed test)

Width of sand bed : 0.5 m

Length of sand bed : 3 m

Time taken : 15 second

Speed : 0.7 kmph

Sl.No.	Number of seeds fallen per hill from each seed tube		
	No.1	No.2	No.3
1	6	6	3
2	4	7	6
3	4	2	5
4	3	4	6
5	0	5	4
6	7	4	2
7	10	3	7

three speeds are shown in Appendix IV. It was found that the C.V. was more or less same for 0.5, 0.6 and 0.7 kmph. It reveals that the uniformity in seeding was more or less same for the three speeds. Thus it was observed that the dibbler could be operated in the range of 0.5 to 0.7 kmph which is the speed that a man is able to operate in the field. So the recommended speed range of the paddy dibbler is 0.5 to 0.7 kmph.

4.2.2 Field capacity and field efficiency

The theoretical field capacity at 0.5 kmph, 0.6 kmph and 0.7 kmph were 0.023 ha/h, 0.027 ha/h and 0.032 ha/h respectively. The effective field capacity obtained at the above said speeds were 0.016 ha/h, 0.0185 ha/h and 0.022 ha/h respectively.

The average field efficiency obtained was 68.68 per cent. The results are shown in Table 8.

The field capacity obtained for the Naveen seed dibbler developed at CIAE, Bhopal was 0.013 ha/h. The field capacity of the present paddy dibbler at the designed speed of 0.7 kmph was 0.022 ha/h which is a better result than that of the Naveen seed dibbler.

4.2.3 Emergence count

The results of the test conducted on sand bed, experimental field and actual field are shown in Tables 9 to 11.

Table 8. Effective field capacity and field efficiency of the dibbler

Trial number	Area covered: Width (m)	Length (m)	Area (ha)	Total time spent (hours)	Effective field capacity (ha/h)	Theoretical field capacity (ha/h)	Field efficiency (%)
1	10	10	0.01	0.633	0.0158	0.0230	68.69
2	10	10	0.01	0.613	0.0163	0.0230	70.87
3	10	10	0.01	0.555	0.0180	0.0270	66.67
4	10	10	0.01	0.526	0.0190	0.0270	70.37
5	10	10	0.01	0.467	0.0214	0.0324	66.05
6	10	10	0.01	0.444	0.0225	0.0324	69.44
Average							68.68

Table 9. Emergence count (Sand bed test)

Actual seed rate : 80 to 90 kg/ha

Recommended row spacing : 15 cm

Actual row spacing : 15 cm

Recommended plant spacing : 10 cm

Size of tray (cm^2)	Observed spacing between hills (cm)			Number of plants per hill		
	1	2	3	1	2	3
2 x 60 x 38	10.0	9.5	9.0	6	3	4
= 4560 sq cm	11.0	10.0	10.0	4	3	4
	12.0	12.0	12.0	4	5	6
	12.0	11.0	11.5	8	6	4
	10.5	10.5	10.0	5	5	5
	11.0	12.0	12.0	8	5	5
	10.0	9.0	10.5	4	6	7

Table 10. Emergence count (Experimental field test)

Actual seed rate : 80 to 90 kg/ha

Recommended row spacing : 15 cm

Actual row spacing : 15 cm

Recommended plant spacing : 10 cm

Size of plot (m^2)	Observed spacing between hills (cm)			Number of plants per hill		
	1	2	3			
3 x 3	11.0	11.0	12.0	8	2	5
= 9 sq m	12.0	11.0	11.5	4	3	6
	10.5	11.0	11.0	0	5	3
	12.0	11.5	12.0	6	7	0
	10.0	10.5	10.0	2	6	5
	11.0	11.0	11.5	7	8	10
	12.0	12.5	12.0	3	0	8

Table 11. Emergence count (Actual field test)

Actual seed rate : 80 to 90 kg/ha

Recommended row spacing : 15 cm

Actual row spacing : 15 cm

Recommended plant spacing : 10 cm

Size of plot (m^2)	Observed spacing between hills (cm)			Number of plants per hill		
	1	2	3			
10 x 10 = 100 sq m	12.0	11.5	10.5	6	2	9
	13.0	12.0	11.5	7	0	4
	11.0	13.0	10.0	3	10	0
	10.5	11.0	12.5	11	2	5
	12.5	10.5	11.0	0	9	7
	11.5	12.5	12.0	8	4	3
	13.5	12.0	13.0	2	11	9

The results showed that the number of plants germinated in a hill was in the range of 4 to 6 and the spacing between hills ranged from 10 to 11. The number of plants and the spacing between them can be seen in Plates 6, 7 and 8 respectively.

The results of the test to find out the percentage losses of seeds after germination is shown in Table 12. The percentage losses of seeds after germination was found to be 9.52. This percentage is more than the visible damage (mechanical damage). The difference in percentage of damage might be due to the mechanical damage during the metering and the non viability of seeds.

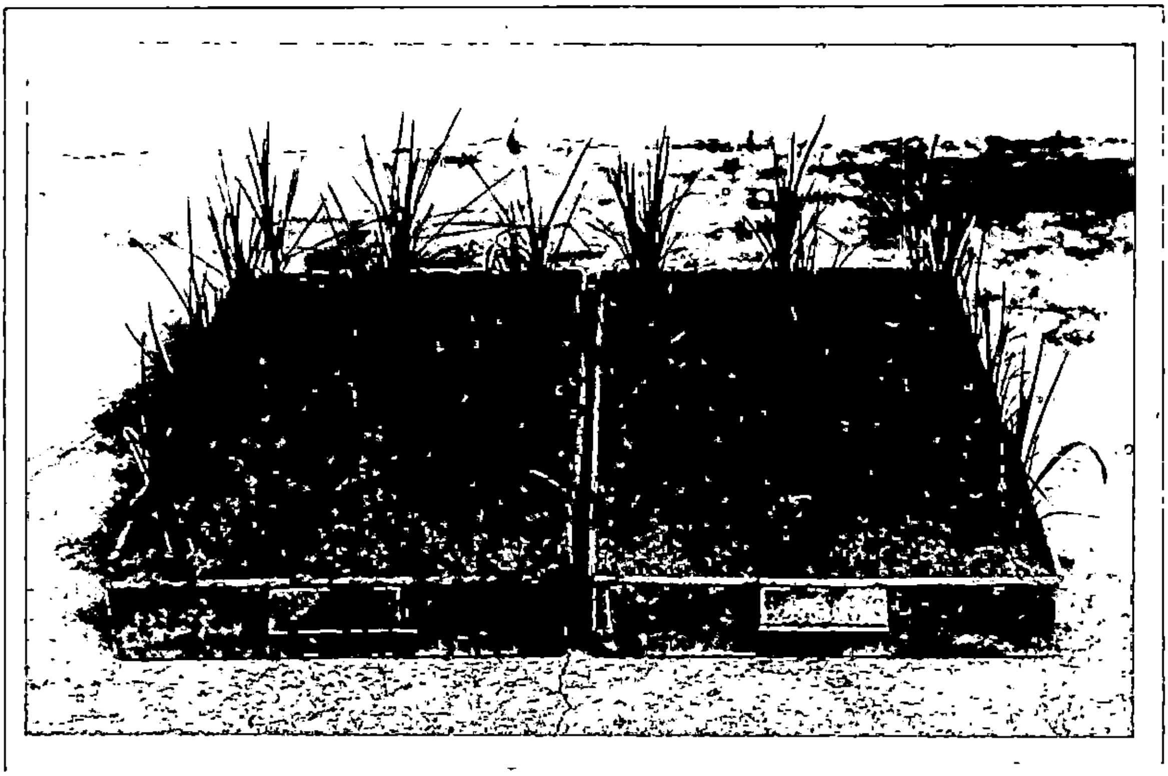
4.2.4 Economic analysis

The calculation of the operating cost of paddy dibbler is given in Appendix V. The annual use and the average life of the equipment was taken as 200 hours and 10 years respectively for the cost analysis. The fabrication cost of the dibbler including cost of material was Rs.800/-. The depreciation was calculated by taking 10 per cent salvage value and the operating cost was obtained as Rs.16/- per hour. The area sown per hour by the dibbler was 0.022 ha. Therefore the cost of sowing one hectare of land is Rs.717/-.

The cost of sowing one hectare of land by manual dibbling behind the plough comes around Rs.979/- (John, 1989).

Plate 6 Paddy planted with dibbler in sand bed test

Plate 7 Paddy planted with dibbler in experimental field test



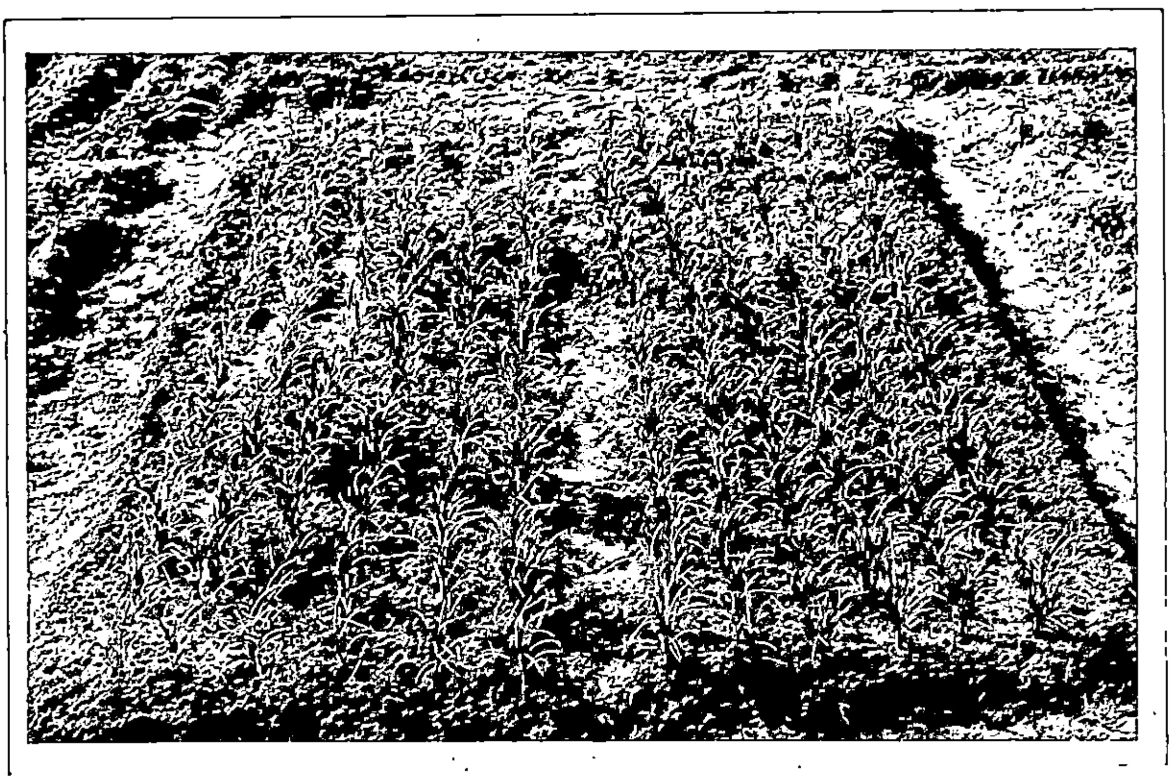


Plate 8   Paddy planted with dibbler in actual field test

Table 12. Percentage losses of seeds after germination

Kind of seed : Paddy

Variety of seed : Jyothi

Rate setting : 4 to 6 seeds/hill

Test number	Number of seeds dropped after 20 times of operation	Germinated seedlings	Percentage losses of seeds after germination
1	110	100	9.09
2	120	105	12.50
3	115	104	9.56
4	100	92	8.00
5	118	108	8.47
Average			9.52

From this it is clear that the cost of sowing one hectare of land by the dibbler is less compared to the manual dibbling. Moreover manual dibbling is done in a bending position which is arduous to the farmer. But in the present design of dibbler, a suitable handle is provided which ensure easy and comfortable operation in a straight posture.

Summary

SUMMARY

A manually operated three row dibbler for dry sowing of paddy was developed and tested. The main emphasis of the study was on the design of metering mechanism to drop the desired number of seeds in hills.

5.1 Features of the equipment

Three seed boxes with a total capacity of 4 kg of paddy seeds were fabricated and assembled on a mainframe with the other components. The top and bottom portion of the seex box was made circular and as truncated cone respectively to obtain the desired volume of 2000 cc. A circular seed tube was connected directly to the bottom of the seed box for guiding the travel of the seeds into the soil.

The roller was the most important feature of the machine. It was used for metering the seeds. The roller was divided into three portions. The top portion helped the insertion of the spring around it. The middle portion contained the vertical slot for metering the seeds. The end of the bottom portion was provided with a collar having spikes around the periphery in order to avoid clogging by clods. It also served for making the hole in the soil.

When the dibbler was operated for dibbling, the roller would move upward by the soil pressure against the spring pressure. As the roller moved upward, the portion of the roller having the vertical slot would come in contact with seeds and the seeds were moved and carried to this slot. When the equipment was taken out from the soil, the soil pressure on the roller was released and due to the spring pressure the roller moved downward and the seeds in the slot were released and would fall through the seed tube by gravity into the soil.

The upward movement of the roller could be varied by varying the relative position of the stopper provided on the roller and the stationary guide ring of the roller. And the downward travel of the roller was limited by the provision of a fixed collar at the top.

There was no separate furrow opener for making the hole. During the operation of the equipment due to the downward travel of the roller and seed tube, the seed hole was created for dropping the seeds.

There was no covering device in this unit. When the dibbler was taken out from the soil the seeds would be covered with the surrounding soil.

A suitable frame was fabricated. Handles were provided

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to operate the equipment. A marker was also provided for marking the hill to hill spacing.

Manual dibbling is done in a bending position which is arduous to the farmer. But in the present design of dibbler, a suitable handle is provided which ensure easy and comfortable operation in a straight posture.

5.2 **The test results are summarised below:**

1. The stroke length of the roller was obtained as 25 mm so that the number of seeds dropped were in the range of 4 to 6 per hill.

2. The average seed rate obtained from the calibration test was 86.03 kg/ha.

3. The mechanical damage was 4.84 per cent.

4. The field efficiency obtained was 68.68 per cent. The area covered by the dibbler was 0.022 ha/h.

5. The percentage losses of seeds after germination was 9.52.

6. The fabrication cost of the dibbler including cost of material was Rs.800/-.

7. The operating cost of the dibbler was Rs.16/- per hour and the cost of sowing one hectare of land was Rs.717/-.

5.3 The following are some of the works suggested for further investigation

1. Testing of the dibbler for different seeds like cowpea, etc. with suitable modified metering mechanism.

2. Suitable modification to this dibbler to mount on a power tiller or a tractor.

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* Originals not seen

Appendices

Appendix I

Checking the uniformity of seeds dropped from each seed tube

Speed : 0.5 kmph

$$t = \frac{\bar{X} - \mu}{S/\sqrt{n-1}}$$

where,

$\bar{X}$ = Sample arithmetic mean

μ = Population arithmetic mean on hypothesis is 5

S = Standard deviation of the sample

n = Number of observation

First seed tube

$\bar{X}$ = 4.71

S = 2.49

$$t = \frac{4.71 - 5}{\frac{2.49}{\sqrt{7-1}}} = -0.28$$

$$|t| = 0.28 < t_{0.05}(6) = 2.447$$

Second seed tube

$\bar{X}$ = 4.857

S = 1.8

$$t = \frac{4.857 - 5}{\frac{1.8}{\sqrt{7-1}}} = -0.19$$

$$|t| = 0.19 < t_{0.05}(6) = 2.447$$

Third seed tube

$$\bar{X} = 4.28$$

$$S = 2.43$$

$$t = \frac{4.28 - 5}{\frac{2.43}{\sqrt{7-1}}} = -0.72$$

$$|t| = 0.72 < t_{0.05}(6) = 2.447$$

Hence the hypothesis that μ ie. the average number of seeds per hill which is taken as 5 is acceptable.

Appendix II

Checking the uniformity of seeds dropped from each seed tube

Speed: 0.6 kmph

$$t = \frac{\bar{X} - \mu}{S/\sqrt{n-1}}$$

First seed tube

$$\bar{X} = 4.71$$

$$S = 3.45$$

$$t = \frac{4.71 - 5}{\frac{3.45}{\sqrt{7-1}}} = -0.20$$

$$|t| = 0.2 < t_{0.05}(6) = 2.447$$

Second seed tube

$$\bar{X} = 5.57$$

$$S = 2.13$$

$$t = \frac{5.57 - 5}{\frac{2.13}{\sqrt{7-1}}} = 0.655$$

$$|t| = 0.655 < t_{0.05}(6) = 2.447$$

Third seed tube

$$\bar{X} = 4.71$$

$$S = 1.66$$

$$t = \frac{4.71 - 5}{\frac{1.66}{\sqrt{7-1}}} = -0.43$$

$$|t| = 0.43 < t_{0.05}(6) = 2.447$$

Hence the hypothesis that μ ie. the average number of seeds per hill which is taken as 5 is acceptable.

Appendix III

Checking the uniformity of seeds dropped from each seed tube

Speed : 0.72 kmph

$$t = \frac{\bar{X} - \mu}{S/\sqrt{n-1}}$$

Where,

$\bar{X}$ = Sample arithmetic mean

μ = Population arithmetic mean on hypothesis is 5

S = Standard deviation of the sample

n = Number of observation

First seed tube

$\bar{X}$ = 4.86

S = 2.95

$$t = \frac{4.86 - 5}{\frac{2.95}{\sqrt{7-1}}} = -0.12$$

$$|t| = 0.12 < t_{0.05}(6) = 2.447$$

Second seed tube

$\bar{X}$ = 4.43

S = 1.59

$$t = \frac{4.43 - 5}{\frac{1.59}{\sqrt{7-1}}} = -0.88$$

$$|t| = 0.88 < t_{0.05}(6) = 2.447$$

Third seed tube

$$\bar{X} = 4.71$$

$$S = 1.66$$

$$t = \frac{4.71 - 5}{\frac{1.66}{\sqrt{7-1}}} = -0.43$$

$$|t| = 0.43 < t_{0.05}(6) = 2.447$$

Hence the hypothesis that μ ie. the average number of seeds per hill which is taken as 5 is acceptable.

Appendix IV

Checking the uniformity of seed dropping at various seeds

First speed = 0.5 kmph

Coefficient of variation = $\frac{\text{Standard deviation}}{\text{Arithmetic mean}}$.

$$C.V. = \frac{\sigma}{\bar{X}} = \frac{2.27}{4.62} = 49.13\%$$

Second speed = 0.6 kmph

$$C.V. = \frac{\sigma}{\bar{X}} = \frac{2.53}{5.14} = 49.22\%$$

Third speed = 0.7 kmph

$$C.V. = \frac{\sigma}{\bar{X}} = \frac{2.21}{4.47} = 49.44\%$$

Appendix V

Calculation of operating cost of the paddy dibbler

Fabrication cost of the dibbler including cost of material	=	Rs.800/-
Working hours per year (H)	=	200 hours
Average life in year (Y)	=	10
Average life in working hours	=	2000
Salvage value (10% of the initial cost)	=	Rs.80/-

I Fixed cost per hour

1. Depreciation

$$= \frac{C - S}{L}$$

$$= \frac{800 - 80}{2000} = \text{Rs.}0.36$$

2. Interest on average investment (12% per year)

$$= \frac{C + S}{2} \times \frac{12}{100} \times \frac{1}{200}$$

$$= \frac{800 + 80}{2} \times \frac{12}{100} \times \frac{1}{200}$$

$$= \text{Rs.}0.26/-$$

Total fixed cost per hour = 0.36 + 0.26

= Rs.0.62/-

II Variable cost per hour

1. Labour cost	=	Rs.15 per hour
2. Repair and maintenance charge (40% of the original price for whole life of the dibbler	=	$800 \times \frac{40}{100} \times \frac{1}{200}$
	=	Rs.0.16
Total variable cost per hour	=	15 + 0.16
	=	Rs.15.16
Total operating cost per hour (I + II)	=	0.62 + 15.16
	=	Rs.15.78
		Say Rs.16/-
Area covered per hour	=	0.022 ha
Cost of sowing	=	Rs.717.27 per ha
		Say Rs.717 per hectare

ABSTRACT

A manually operated three row paddy dibbler for dry sowing was developed and tested at Kelappaji College of Agricultural Engineering and Technology, Tavanur. The metering mechanism employed in this dibbler was unique in design.

The machine consists of seed box, roller with metering mechanism, seed tube with furrow opener, frame, handles and marker. When the dibbler was operated for dibbling, the roller passing vertically through the centre of box would move upward by the soil pressure against the spring pressure. As the roller moved upward, the portion of the roller having the vertical slot would come in contact with seeds and the seeds were moved and carried to this slot. When the equipment was taken out from the soil, the soil pressure on the roller was released and due to the spring pressure the roller moved downward and the seeds carried in the slot were released and would fall through the seed tube by gravity into the soil. During the operation of the equipment due to the downward travel of the roller and seed tube the seed hole was created for dropping the seeds. The covering of seeds with soil was carried out automatically when the equipment was taken out from the soil. The number of seeds dropped were in the range of 4 to 6 per hill.

The area covered by the dibbler was 0.022 hectare per hour. The field efficiency obtained was 68.68 per cent. The mechanical damage was 4.84 per cent. The percentage losses of seeds after germination was 9.52.

The fabrication cost of the dibbler including cost of material was Rs.800/-. The operating cost of the dibbler was Rs.16/- per hour. The cost of sowing one hectare of land was Rs.717/- while for manual dibbling the cost of sowing was Rs.979/- per hectare. Moreover manual dibbling is done in a bending position which is arduous to the farmer. But in the present design of dibbler, a suitable handle is provided which ensure easy and comfortable operation in a straight posture.

The equipment can be fabricated locally with readily available materials and can be easily maintained by small farmers.